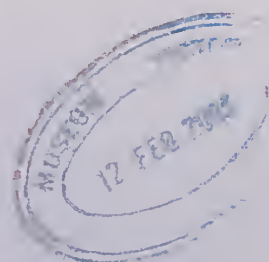


# *The* *Beagle*

*Records of the Museums and Art Galleries  
of the Northern Territory*

Volume 18

December 2002



*The Beagle, Records of the Museums and Art Galleries of the Northern Territory*  
(formerly 'Records of the Northern Territory Museum of Arts and Sciences')

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ISSN 0811-3653

Printed by the Government Printing Office of the Northern Territory



**Northern Territory Government**

Department of Community Development, Sport & Cultural Affairs

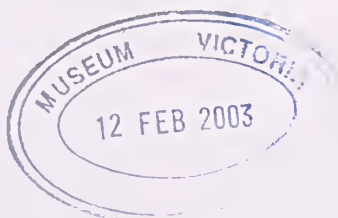


**Front cover:** Colour forms of the ascidian, *Sycozoa seiziwadai*, from Darwin Harbour (see Kott, pages 19–55). Photograph copyrights: Shallow Water Marine Collection Taxonomy Program, US National Cancer Institute.



# The Beagle

RECORDS OF THE MUSEUMS AND ART GALLERIES  
OF THE NORTHERN TERRITORY



Volume 18, December 2002

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## A new soft coral genus (Coelenterata: Octocorallia) from Palau

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### ABSTRACT

*Elbeenus lauramartinae*, a new genus and species of the soft coral family Alcyoniidae from deep (159 m) water off Palau is described. The lobed colonies bear a resemblance to some species of *Simularia* or *Klyxum*, but unlike these genera the coenenchymal sclerites consist of large interior spindles only. Colonies have very large polyps armed with large collaret and points sclerites that are characteristic of some species of the Nephtheidae and Nidaliidae.

KEYWORDS: new genus, new species, soft coral, Coelenterata, Cnidaria, Octocorallia, Alcyoniidae, Palau.

### INTRODUCTION

The new genus and new species, which are the subject of this paper, was collected by the Coral Reef Research Foundation (CRRF), which is based in Palau. The CRRF is contracted to the American National Cancer Institute to collect marine invertebrates in regions of the Indian and Pacific Oceans for natural products research. It has been my fortune for a number of years to investigate their soft coral collections from localities as divergent as South Africa and American Samoa, and this is just one of many new octocoral taxa discovered by the CRRF's team of professionals.

The new genus is placed in the Alcyoniidae, but has some characters that suggest strong links with taxa currently included in the Nidaliidae, and somewhat lesser with the Nephtheidae.

The notation NTM represents the Museum and Art Gallery of the Northern Territory.

### SYSTEMATICS

#### Family Alcyoniidae Lamouroux

##### *Elbeenus* n. gen.

**Type species.** *Elbeenus lauramartinae* new species, by original designation.

**Diagnosis.** Colonies with soft, flexible, branched lobes, extending from a base that may be made rigid in the lower-most regions by an outer layer of large spindles. Colony interior with wide gastric canals, and sparsely distributed large spindles that are often visible through the transparent surface of the lobes. Polyps large and retractile, armoured with a strong collaret and points arrangement. Tentacles with papillae on the oral face between the pinnule rows, and armoured with rods,

often quite large, that, proximally, are basically arranged in two series. Colonies are azooxanthellate and sclerites are colourless.

**Remarks.** Although the morphology of colonies of species of Alcyoniidae may be unbranched (cigar- or carrot-like) or broadly encrusting (thick or membranous), in most there is a bare basal section (termed the stalk or trunk) and an upper, polyp-bearing part which may be flat or undulate, loosely pleated around the margin, or divided into lobes, ridges or short branches. Coenenchymal sclerites of alcyoniids include tuberculate or prickly spindles, clubs, 6- or 8-radiates, ovals and dumbbells, and the interior of a colony may appear compressible and jelly-like if the sclerite content is low, and rigid and solid if it is high. Calyces may be present and polyps may be small or large, and retractile or non-retractile.

The new genus clearly conforms to these criteria, and undoubtedly bears a considerable morphological resemblance to some species of *Simularia* and *Klyxum*. It is worth noting, however, that although large polyps with a strong collaret and points arrangement are found in alcyoniids, for example *Eleutherobia* (Verseveldt and Bayer 1988), and although the restriction of the coenenchymal sclerites to spindles is found in the alcyoniid *Skammarium* Alderslade, 2000, the occurrence of these two characteristics together is suggestive of genera in families other than Alcyoniidae. *Eleutherobia* and *Skammarium* are easily distinguished from *Elbeenus* n. gen. The polyps of *Eleutherobia* generally have extremely large numbers of both point and collaret sclerites, the colonies are nearly always digitiform, and the coenenchymal sclerites are commonly 8-radiates and capstans, or derivatives of these. The only known species of *Skammarium* forms pedestal-shaped colonies, and the polyps are small, confined to the flat or dish-shaped summit and are devoid of sclerites.

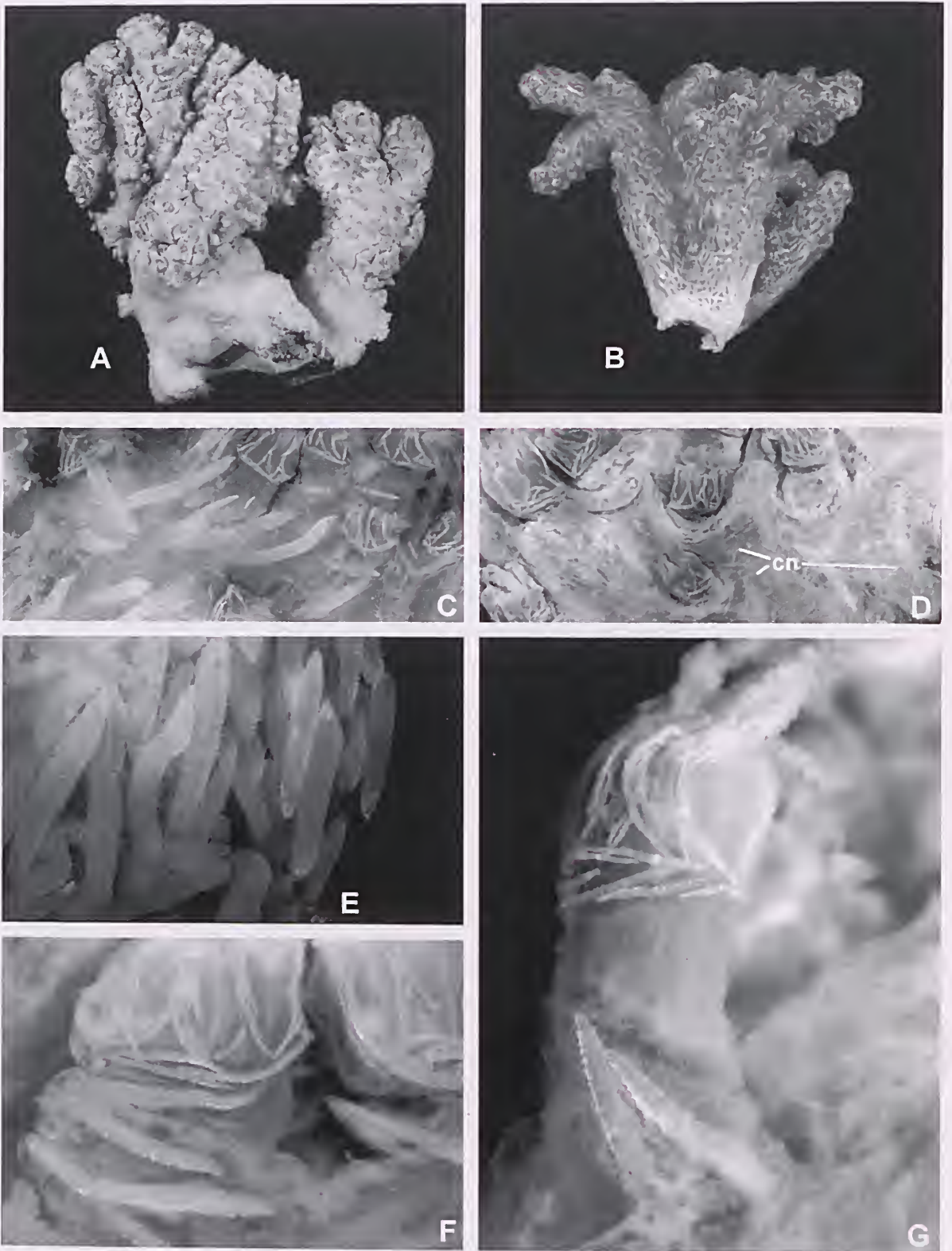


Fig. 1. *Elbeenus lauramartinae* n. gen., n. sp.: A, holotype (NTM C13108), life size; B, picture of lost colony, exact size unknown. C-G, holotype: C, D, lobe surface; E, base surface; F, G, interior sclerites protruding onto the surface below a polyp. Abbreviation: cn = subsurface canals.



Of the non-alcyoniid genera, there are only two that warrant comparison: *Scleronephthya* (Nephthidae) and *Nephthyigorgia* (Nidaliidae) (see Fabricius and Alderslade 2001: 110, 132, for colour pictures and generic descriptions). Both have relatively large polyps with a collaret and points arrangement, and both (with the single exception of *Scleronephthya pustulosa* Wright and Studer, 1889) have only spindles in the coenenchyme. *Elbeenus* n. gen. can be clearly distinguished from these taxa because both have a dense covering of surface spindles over the whole colony. Although a rigid coating may occur in the basal region of *Elbeenus* n. gen, the extent of this may simply be a response to the nature of the substrate and local turbulence (see below). In addition to having a covering of surface sclerites, *Scleronephthya* has polyps with a very complex armature of clubs, spindles and tentacle scales, and *Nephthyigorgia* has prominent calyces.

Although the two non-alcyoniid genera are clearly distinguishable from *Elbeenus*, the aforementioned similarities bring into question the familial placement of all three genera. *Nephthyigorgia* Kükenthal, 1910 is presently grouped in the Nidaliidae (Kükenthal (1910) placed his new genus *Nephthyigorgia* in the Siphonogorgiidae, but the family was later called Nidaliidae (Utinomi 1958: 113–116)). The few genera in the Nidaliidae have several major characters in common: colony stiffness provided by large spindle-shaped sclerites, the presence of calyces, and relatively large, retractile, well-armoured polyps. There are two subfamilies: the Nidaliinae, which includes *Nephthyigorgia* and several other genera with species also shaped rather like some soft corals of other families; and the Siphonogorgiinae, which includes highly branched forms that look much like gorgonians. Both groups are characterised by the fact that the colonies are stiff, often brittle, because their outer walls are constructed of large, longitudinally arranged tuberculate spindles, surrounding the large canals of the primary polyps. In those species that resemble gorgonians, the branches, and often the stalk, do not have a medulla, are easily broken, and essentially consist of thickly packed spindles with a few, narrow, longitudinal canals in the centre. In contrast, the Nidaliinae includes small colonies that are unbranched and torch-like, or have small numbers of lobes or finger-like branches. In these, the outer wall of sclerites is thin and surrounds a gelatinous interior, with broad canals and few sclerites. I feel that in all probability the family will be shown to be polyphyletic, and that *Nephthyigorgia* and the other non-gorgonian-like nidaliid genera may be better placed in the Alcyoniidae. The alternative of placing *Elbeenus* n. gen. in the Nidaliidae would necessitate a radical change of that family's definition to allow the inclusion of soft bodied species. A more detailed discussion of the validity of

this family grouping awaits the results of DNA work being carried out by Prof. C. McFadden, Hervey Mudd Institute, California, and her associates.

Given that the coenenchymal sclerite component of species of *Scleronephthya* is virtually all relatively large spindles, it has little in common with the sclerite component of the other genera in the Nephthidae, which more commonly comprise prickly needles, leafy clubs, irregular shaped spiky forms, and tuberculate and thorny spindles often extensively ornamented along one side (Fabricius and Alderslade 2001). It appears the genus was placed in the Nephthidae by Wright and Studer (1889), primarily because the growth form of the type species has polyps that do not retract into a calyx, and are clustered in groups on the terminal twigs. The latter indicating a characteristic canal system where a small number of broad primary polyp canals split into groups that extend up into the distal lobes and branches where they join with the polyp cavities. My research indicates that in many species, very large numbers of the polyps are often singly arranged on the stems and branches with little arrangement in groups, so indicating a canal system perhaps more akin to that found in the Alcyoniidae. Indeed, the Japanese species, *Alcyonium gracillimum* Kükenthal, 1906a, was recognised as an alcyoniid for nearly 100 years before being transferred to *Scleronephthya* (Alderslade 2000). Once again, a more detailed discussion awaits the results of Prof. McFadden's DNA research. Though it cannot be denied that live expanded colonies of the genus do have a general nephtheid aspect (Fabricius and Alderslade 2001: 104–125), *Scleronephthya* may eventually prove to have more in common with genera other than those in the Nephthidae.

**Etymology.** A combination of letters – gender masculine.

*Elbeenus lauramartinae* n. sp.

(Figs 1-5)

**Type material.** HOLOTYPE - NTM C13108, western side of Uchelbeluu Reef, Koror, Palau, 07°16.41'N, 134°31.34'E, depth 159 m, 28 March 2001, coll. Laura Martin, aboard the *DeepWorker* submersible.

**Description.** The lobed colony, which branches more or less in one plane, is 74 mm tall, 69 mm across and about 30 mm at its thickest point (Fig. 1A). It consists of a short, rigid basal region producing two main stems that divide into finger-like lobes, some of which re-divide once or twice (it is probable that the smaller stem is a daughter colony that was in the process of separating from the larger parent). The lobes are very soft and flexible and bear numerous large polyps; most of which are exert and well spaced. The surface of the polypary is relatively transparent and a broad network of interconnecting canals (Fig. 1D) permeates just

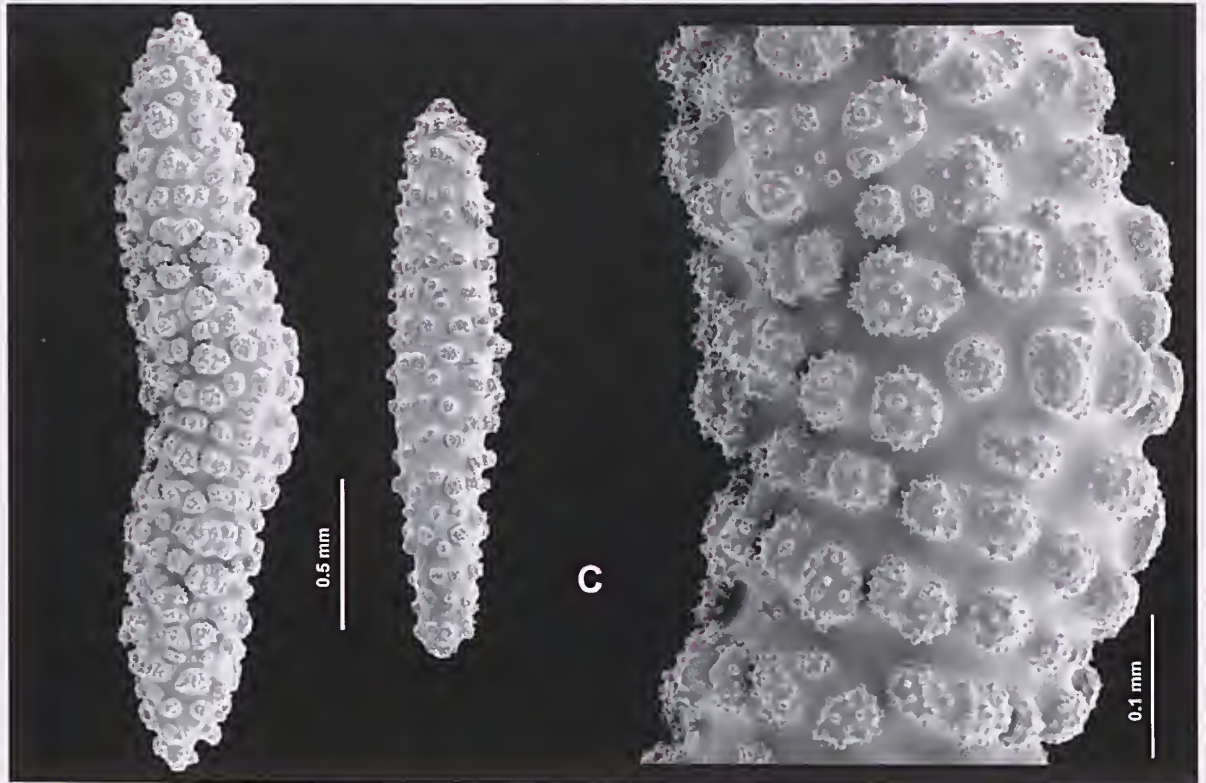
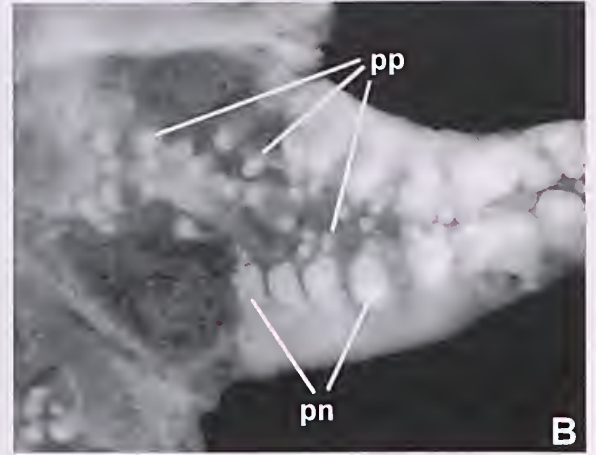


underneath. These canals are often particularly wide and conspicuous in the region immediately below a protruding polyp. Some long, spindle-shaped sclerites can also be seen below the surface here and there (Fig. 1C, D), as well as some opaque polyp pharyngeal zones, and mesenteries together with their attached, spherical, reproductive products.

The common base, and the lower part of both main branches, are rigid due a surface layer of large spindles (Fig. 1E). Most lie in a more or less longitudinal direction, but they are criss-crossed in the most basal

parts for extra strength. The surface of the lobes is, in general, free of sclerites, however, occasionally some interior sclerites protrude through, or actually occur on, the surface immediately below visible polyps (Fig. 1F, G). The latter is mostly restricted to the proximal region of the polypary and in a few cases the sclerites resemble a polyp support.

The spindles of the common base are up to 6.2 mm long and 0.9 mm wide, and may be straight or curved (Fig. 2C). They have large, rounded to cylindrical tubercles that are ornamented with short, jagged processes;



**Fig. 2.** *Elbeenus lauramartinae* n. gen. n. sp., holotype: **A**, polyp tentacles; **B**, oral surface of tentacle showing papillae; **C**, basal sclerites with sectional enlargement of the larger sclerite. Abbreviations: **pp** = papillae, **pn** = pinnules, **tr** = tentacular rods.

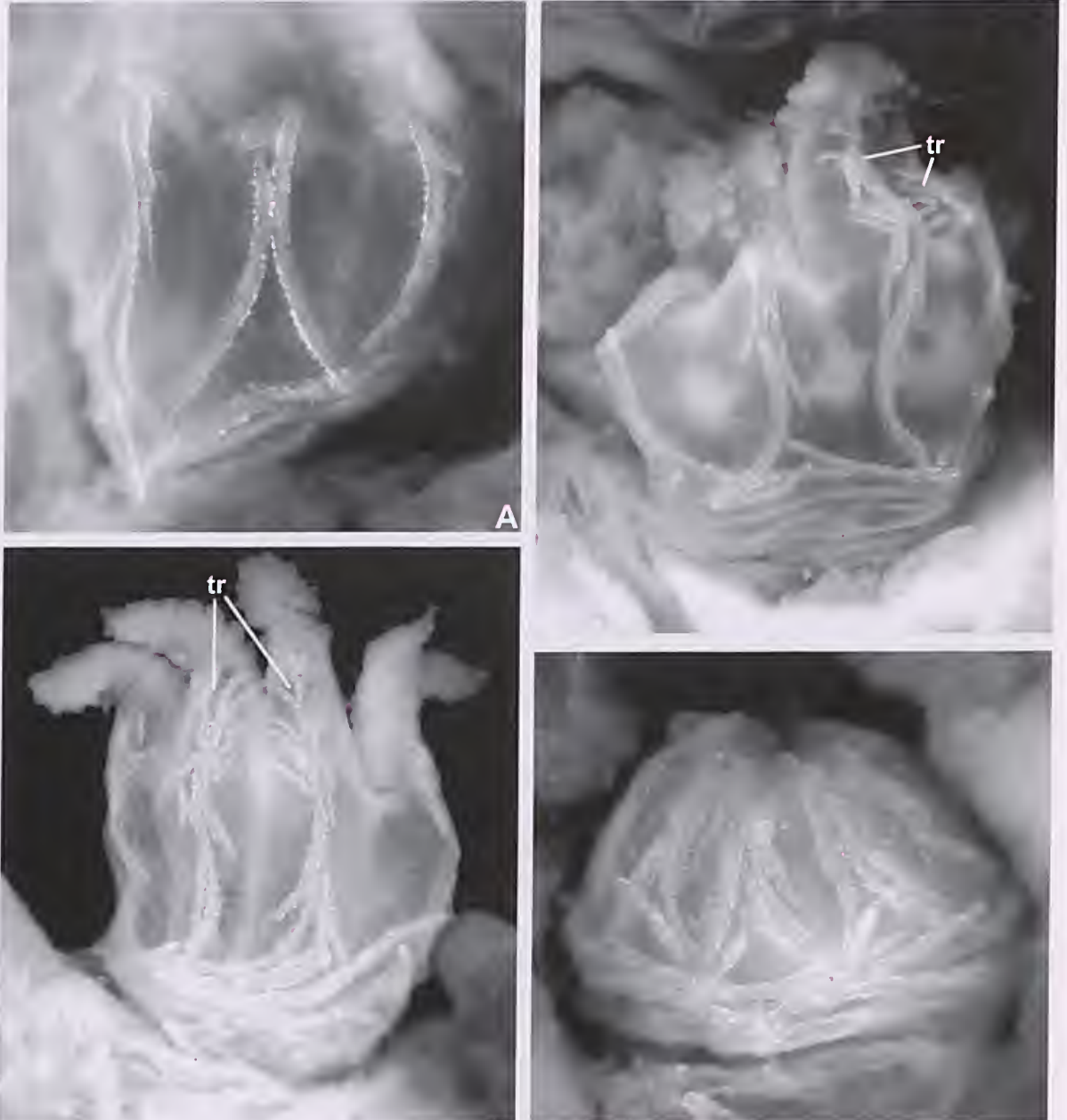




**Fig. 3.** *Elbeenus lauramartinae* n. gen., n. sp., holotype, polyps showing sclerite arrangements. Abbreviations: sp = supra-point sclerites, tr = tentacular rods.

the ornamentation on the inner surface of the sclerite being more complex than that on the outer surface. The interior of the colony also contains spindles, but these are very sparsely distributed in the walls of the wide gastric canals, and, with minimal dissection, seem to occur more towards the surface. These spindles can often be seen through the lobe surface and are generally quite isolated, but in few places they are quite numerous (Fig. 1C). They are smaller and thinner than the basal sclerites, up to 3.5 mm long and 0.15 mm thick, and the large tubercles only have small, angular, cone-like processes.

The majority of the polyps are contracted to such an extent that only the head projects from the coenenchyme, but a few have an extended neck region that may be up to 1.6 mm in length (Fig. 1G). In some polyps, the tentacles are folded in above the mouth, but in many they still protrude, though they are very short. A small proportion of polyp heads only partially protrude, while several others are completely retracted to just below the surface. Polyp heads are mostly about 2 mm in diameter, with the range being about 1.6–2.3 mm.



**Fig. 4.** *Elbeenus lauramartinae* n. gen., n. sp., holotype, polyps showing sclerite arrangements: A, point sclerites exceptionally long, no supra-points. Abbreviation: tr = tentacular rods.



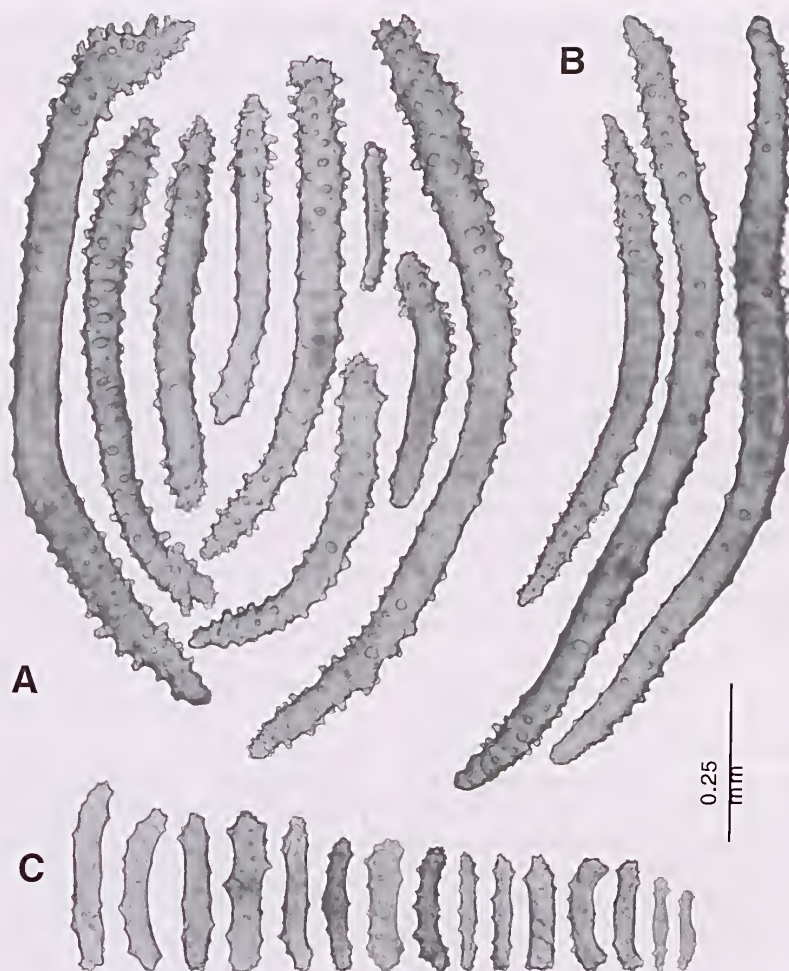


Fig. 5. *Elbeenus lauramartinae* n. gen., n. sp., holotype sclerites: A, points and supra-points; B, collaret; C, tentacular rods.

The tentacles have a single row of about 14–15 pinnules along each edge. Unusually, however, on the oral face there are scattered papillae (Fig. 2B), which are perhaps homologous to the structures described and figured by Kükenthal (1906b: 20 and pl.5, fig. 22) for the specimen he named *Xenia antarctica*.

The number and arrangement of the polyp sclerites is very variable (Figs 1G, 3, 4), and is not abaxially/adaxially symmetrical. On the abaxial face, the collaret consists of 1–3 (rarely 4) 'rows' of very thin, curved, spindles. These may be all short, all long, or a mixture, but no organised rows are present. On the adaxial face, the number and size of the collaret sclerites are reduced, and commonly there are none. The central region of a collaret sclerite is relatively smooth. The tubercles on the rest of the sclerite are usually cone-like or tooth-like, and may have a few prickles (Fig. 5B).

Above the collaret, on the abaxial face, lie the point sclerites. In simplest form, an octant may contain just a single, thin, spindle that may be curved or straight.

More commonly there are two long, curved spindles, however, smaller additional sclerites may increase the number in an octant to about 5 (rarely 6). In some cases when there are only 2–3 curved sclerites in an octant, they may lie parallel to each other instead of the curves being opposed to form a chevron. The arrangement of the points is only left/right symmetrical when just two chevroned sclerites occur. On the adaxial face of the polyp the point sclerites are noticeably smaller and fewer, and often just a small, single spindle will occur in each octant.

Distal to the point sclerites, on the abaxial side of the polyp, there is commonly one or more longitudinally arranged supra-point spindles that bridge the distance to each tentacle base (Fig. 3). The proximal part of these short sclerites overlaps the distal part of the point sclerites. Sometimes, however, one or more point sclerites are exceptionally long and extend from the collaret to the tentacle base and no supra-points are present (Fig. 4A). The supra-point sclerites are not

visible if the tentacles have been folded in over the mouth. In the adaxial octants these sclerites are smaller or absent.

Like a collaret sclerite, a point and supra-point sclerite has a relatively smooth zone that is more or less centrally placed. The rest of the sclerite has somewhat jagged, cone-like or tooth-like tubercles (Fig. 5A).

In the rachis of each tentacle there are numerous rods (Figs 2–4), the proximal ones being much larger than the distal ones. In a relatively expanded tentacle, the proximal rods are arranged in two series, one on each side of the aboral face, forming irregular chevrons with the apex of the 'V' directed toward the polyp mouth. Distally, the smaller rods tend to lie transversally. In less expanded tentacles, all rods commonly lie transversally in a single row. In more contracted tentacles, the arrangement is disrupted and the proximal rods often appear grouped longitudinally. The arrangement and number of sclerites in both abaxial and adaxial tentacles seem to be much the same. The rods have a few cone-like tubercles (Fig. 5C).

When alive, the base of the colony was cream coloured, the lobe surface grey-blue, and the polyps a rich brown to reddish brown (L. Martin: field notes). The specimen in its preserved state is slightly paler, and the polyps are much paler.

**Remarks.** A second colony of the species was obtained about 100 metres from the first at about the same depth, but unfortunately only a photograph remains (Fig. 1B). This colony does not appear to have the same extent of sclerite-reinforced base as the holotype, the thickly clustered sclerites being restricted to the basal rim, at least on the side of the colony that appears in the photograph. This indicates that the basal reinforcement is variable and is probably only a response to local conditions. This second colony was browner overall than the holotype and most of its polyps were retracted. In the photograph the interior spindles can clearly be seen through the colony surface.

**Etymology.** I am delighted to name this species after Dr Laura Martin, Coral Reef Research Foundation, Palau, who collected the holotype while aboard the *DeepWorker* submersible.

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Accepted 20 November 2002



## Description of a new bathyal species of *Calliostoma* (Mollusca: Trochoidea: Calliostomatidae) from the Arafura seaway

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### ABSTRACT

*Calliostoma bellatrix* n. sp. is described from depths of 250 to 400 metres depth in the seaway between northern Australia and the southern Indonesian archipelago, and extending into the eastern Indian Ocean. Its smooth shell, with flat sides to the whorls and an acutely angled periphery ornamented with a “double” nodulose keel, render it unique among Indo-Pacific calliostomes, and it may be the sister species to *C. schroederi* Clench and Aguayo from similar depths in the Caribbean Sea. Both *C. bellatrix* and *C. schroederi* clearly belong within the subgenus *Ampullotrochus* Monterosato.

KEYWORDS: Trochoidea, Calliostomatidae, new species, *Calliostoma bellatrix*, taxonomy, biogeography.

### INTRODUCTION

Nine years ago, Wilson included two coloured illustrations of a distinctive, undescribed calliostome (i.e., a species of top shell in the family Calliostomatidae) to embellish the Introduction to his first volume on Australian marine shells (Wilson 1993: 20). However the species was neither named nor mentioned further in this book, presumably because of lack of material. Additional specimens of this species have now become available from vessels trawling for scampi (Crustacea: Nephropidae) in the Arafura seaway (i.e., the collective name for the Arafura and Timor Seas). In addition, two monographs have appeared dealing with the taxonomy of the family in the southwestern Pacific Ocean (Marshall 1995a,b), so that the species can now be described as new in *Calliostoma* (*Ampullotrochus*).

Calliostome shells are conical (shaped like a spinning top) as is generally characteristic for all trochoideans with an oblique aperture and all have an oblique angle where the relatively straight columella meets the lower section of the outer lip. The outer lip is generally not thickened and is never denticulate. There is generally a sharp peripheral demarcation, which may be reinforced with a thickened spiral cord, between the spire and the base of the shell. Spiral cords, either smooth or ornamented with regular nodules, are the predominant sculptural component on the exterior of the shell. The honeycomb-like microsculpture on the protoconch of the shell is a derived character diagnosing the family, as are the projecting papillae on the oral disc of the animal, the prominent pseudoproboscis, the cuticularised lining of the buccal

cavity, and the radular structure and ontogeny. The radula (in all genera except *Fautrix*) contains an elongate rachidian (central) tooth with numerous fine denticulations plus numerous lateral teeth that are all finely denticulate. Both the rachidian and the laterals have the blade set at an acute angle from the broad, thin, flat basal plate. The innermost marginal tooth is enlarged as a heavy, hooked, laterally flattened element (Hickman and McLean 1990; Hickman 1998). Warén (1990) demonstrated the ontogeny of the radula, in which, uniquely within the Trochoidea, the lateral teeth arise through intercalation within the central field rather than by the usual vetigastropod transformation of marginal teeth into laterals.

All these apomorphies clearly demonstrate the monophyly of the Calliostomatidae. Therefore, on phylogenetic grounds, I follow Marshall (1995a,b) in treating it as a family, instead of a subfamily of the Trochidae, as has been taxonomic practice since Thiele (1929), certainly in modern Australasian literature (e.g., Powell 1979; Marshall 1979, 1988, 1994, 1985a; Wilson 1993; Hickman 1998; Wilson 1993; Spencer and Willan 1996). Recognition of the Calliostomatidae as a monophyletic family distinct from the Trochidae *sensu lato*, does not however render the latter monophyletic, so placement of the calliostomes cannot yet be considered settled. Marshall (1995b: 384) predicted resolution of phylogenetic groups within the Calliostomatidae would be “extremely and unusually difficult” and the description of this new species vindicates his prediction. Many of the species are uncommon or rare, and the majority are from deep water, so a comprehensive genetics study is unlikely for a long time to come.

The family Calliostomatidae comprises about 250 Recent species (Marshall 1995b). An austral centre of calliostome biodiversity has long been considered because of the high diversity of the group in New Zealand and Australian waters. Marshall's (1995a) recent monograph of the New Zealand fauna, wherein 33 endemic species of this group are recorded, has strongly reinforced that impression. The Australian calliostome fauna contains more than the 24 species recorded by Wilson (1993) (Marshall pers. comm., August 2002). Not a single calliostome species is common to both New Zealand and Australia. It now seems that the centre of biodiversity is actually in the wider southwestern Pacific Ocean, rather than strictly in the Australia-New Zealand continental regions, because Marshall (1995b) recorded 30 species from New Caledonia, the Loyalty Islands and the northern Lord Howe Rise and Spencer *et al.* (in press) list 40 species from the New Zealand Exclusive Economic Zone (i.e., the New Zealand shelf plus Kermadec Ridge).

The present new species was certainly not described by Schepman (1908) in the *Siboga* Expedition report, although his samples were from the same area and depth.

Coding for spiral cords on shells follows Marshall (1995b: Fig. 1), wherein P = primary spiral cords and S = secondary spiral cords. These cords are numbered in series from the upper (apical) suture. Height precedes diameter (herein termed 'width') in all given dimensions. All shell measurements were made on the shell's longitudinal axis, or at right angles to it. Abbreviations for institutions cited here are: MNZ, Museum of New Zealand Te Papa Tongarewa, Wellington; NTM, Museum and Art Gallery of the Northern Territory, Darwin; WAM, Western Australian Museum, Perth.

## SYSTEMATICS

### *Calliostoma bellatrix*, new species

(Figs 1A–F, 2)

**Type material.** HOLOTYPE - NTM P17143 (height 28.2 mm, width 31.7 mm, 9 teleoconch whorls, live), Arafura Sea, SE of Pulau Yamdena, Tanimbar Islands, 260–300 m depth, March 2001, coll. G.A. Cheeseman on *FV Fukui Maru*, c. 08°00'S, 132°00'E (Fig. 1A,B). PARATYPE - NTM P20242 (height 26.9 mm, width

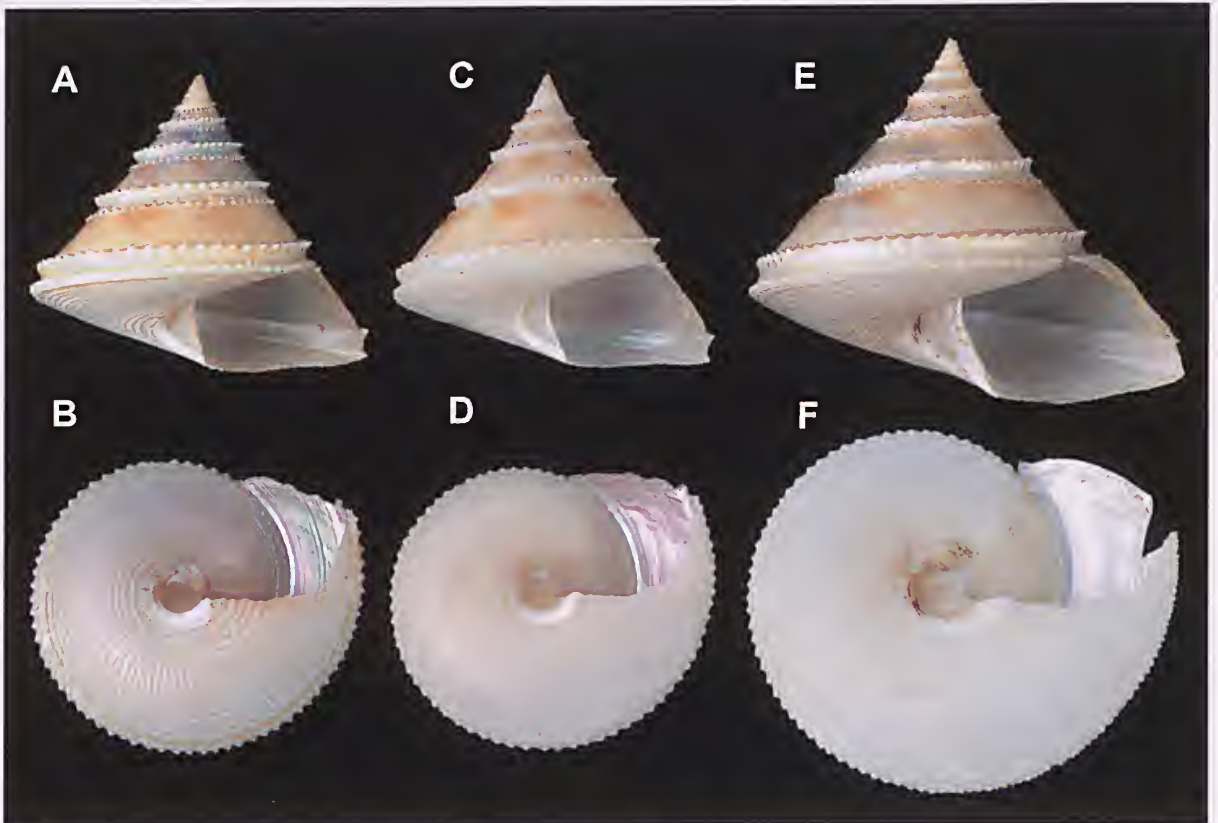


Fig. 1. *Calliostoma bellatrix* n. sp. A, B, holotype, NTM P17143, height 28.2 mm, width 31.7 mm, Arafura Sea, SE of Pulau Yamdena, Tanimbar Islands, 260–300 m depth; C, D, paratype, NTM P20242, height 26.9 mm, width 30.4 mm, Timor Sea, SE of Pulau Roti, Timor, 250 m depth; E, F, WAM S14251, height 33.6 mm, width 40.9 mm, off Rowley Shoals, 400 m depth.



30.4 mm, 8.5 teleoconch whorls, live), Timor Sea, SE of Pulau Roti, Timor, 250 m depth, 14 April 2002, coll. G.A. Cheeseman on *FV Orion*, c. 12°00'S, 124°00'E (Fig. 1C,D).

**Additional material examined (non-type material).** WAM S14252 (2 shells: specimen 1 live – height 27.2 mm, width 30.6 mm, 9 teleoconch whorls: specimen 2 dead – height 30.1 mm, width 27.9 mm, 9 teleoconch whorls), Arafura Sea, N of Darwin, 300 m depth, pre May 1988, coll. unknown, 11°05'S, 132°14'E; MNZ M.273186 (height 27.4 mm, width 32.4 mm, 9 teleoconch whorls, live), Arafura Sea, off Tanimbar Islands, 300 m depth, 1998, coll. unknown; WAM S14251 (height 33.6 mm, width 40.9 mm, 9.5 teleoconch whorls, live), off Rowley Shoals, 400 m depth, pre April 1986, coll. J. Rinkens, 17°20'S, 119°10'E (Fig. 1E,F) (= specimen illustrated by Wilson (1993: 20), but outer lip now broken).

**Description.** Based on shells of six specimens listed above (animal unknown). Shell up to 40.9 mm high, broader than high, aperture 44 % height of spire, glossy, fragile, outer shell layer very thin, spire evenly conical to coeloconid in profile, mean spire angle 71.2° (range 66° to 82°), sides of whorls straight, periphery angulate, anomphalous.

**Colour** of protoconch and first 5 teleoconch whorls uniform cream, weakly nacreous; 6<sup>th</sup> and subsequent teleoconch whorls pink-buff (golden-apricot when live), nacreous (due to transparency of extremely thin outer shell layer), with broad, brown, opisthocline blotches or flames, strongest at suture, generally not extending beyond middle of whorl and never extending to periphery, spiral rows of nodules uniformly pale cream to almost white, rarely maculated with pale brown; base paler than top of shell, cream-buff; inner shell layer pink and nacreous; periostracum absent.

**Protoconch** consisting of 1 whorl, 0.45 mm wide, tightly coiled, evenly rounded, with honeycomb-like microsculpture, terminating in a distinct varix; very fragile – lost (through dissolution or dehiscence) in four of the specimens.

**Teleoconch** with average of 9 (range 8.5 to 9.5) whorls, but sutures very indistinct. First 0.25 whorl rounded, with 3 primary rows of spiral cords (P3 strongest, P2 weaker, P1 weakest). Remaining 0.75 of first whorl plus next 2 whorls with flattened sides and sculptured with 3 primary rows of sharp, strongly nodulose spiral cords (P3 strongest, P1 weaker, P2 weakest), nodules in rows on cords and interconnected between rows by strong oblique axial costae; costae commence on P1 (i.e., not at upper suture) and extend to lower suture without diminution. P2 and axial ribs rapidly weaken on whorls 3 and 4, so that P2 is merely a low, rounded thread on whorl 4. Both P2 and axial ribs totally absent on whorl 5 and all subsequent whorls. Whorls 5 to 9 straight sided (to slightly convex see below); S3 (there being no S1 or S2) first detectable on

whorl 5 as a series of weak nodules at lower suture, rapidly increasing to narrow, sharp (but unthickened), nodulose spiral cord at peripheral angle equal in strength to P3. All whorls subsequent to 5, have P1 as a series of rounded nodules at upper suture, an extensive, macroscopically smooth (actually with up to 10, microscopic, narrow, rounded, additional spiral cords) intervening section (without any trace of P2), P3 as a series of (approximately 60) very strong, sharp nodules immediately above periphery, and S3 as a series of nodules at periphery equal in strength to P1. Prominence of P3 and S3 on periphery impart a distinctive “double-keeled” appearance to acute angled periphery of shell. Ontogeny of sculptural elements illustrated in Figure 2. Base flat, with 15–19, sharp-sided weakly nodulose spiral cords, decreasing in strength inwards from periphery, and interconnected by microscopic oblique radial threads; narrow central zone usually smooth (see below); innermost section with 3 or 4 rows of moderately strong nodulose spiral cords and a broad, white, thickened cord flanking infilled umbilical depression. Aperture oblique, subquadrate, acutely angled at periphery, obtusely angled abapically where columella meets lower section of outer lip. Outer lip very thin at rim (broken in all specimens), not thickened anywhere.

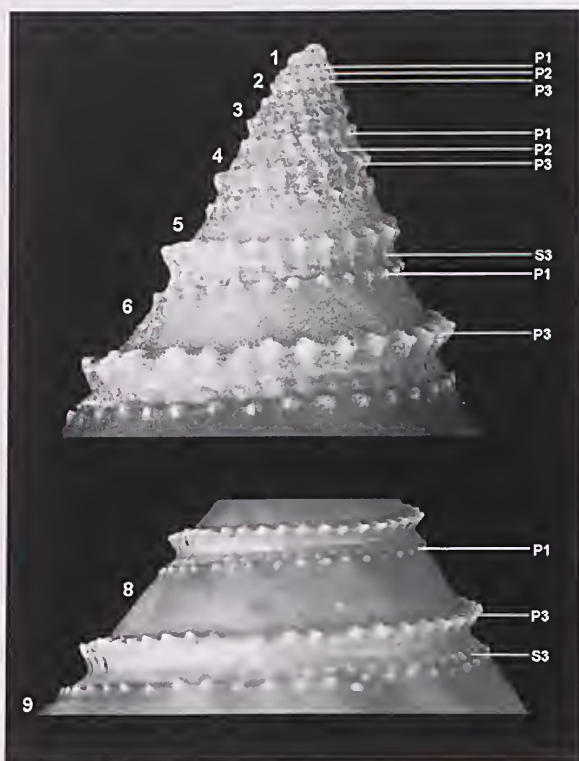


Fig. 2. *Calliostoma bellatrix* n. sp. Composite diagram to illustrate ontogeny of sculpture on teleoconch whorls on a single shell, WAM S14252, height 27.2 mm, width 30.6 mm, Arafura Sea, N of Darwin, 300 m depth. Whorls numbered on left and spiral cords indicated on right.



Inner lip a convex, spreading glaze over entire columella. Operculum (retained in only NTM P20242) circular, multispiral, pale brown, transparent, sculptured with very fine radial threads.

**Distribution.** *Calliostoma bellatrix* is now known to occur in a wide arc in the seaway between northern Australia and the southern Indonesian archipelago – from the Arafura Sea north of Darwin, through the Timor Sea, westwards to west of the Rowley Shoals off northern Western Australia. It lives off the continental shelf between 250 and 400 m in depth.

Judging by the specimens brought in by the scampi trawlers, the dominant benthic species co-occurring with *Calliostoma bellatrix* in these soft bottom, bathyal communities are the bivalves *Acesta rathbuni* (Bartsch) (Limidae) and the crustaceans *Tisea grandis* Morgan and Forest (Diogenidae), *Chaceon* sp. (Geryonidae), *Neolithodes* sp. (Lithodidae), *Platymaia* (Majidae) and *Metanephrops* sp. (Nephropidae).

**Remarks.** *Calliostoma bellatrix* is distinguished from all the other described calliostomes by the combination of its thin shell, flat-sided whorls, complete suppression of P2 to render the central section of the whorls (macroscopically) smooth, presence of only a single secondary spiral cord (S3, on the periphery) which, together with P3, produce a sharp nodulose (almost spined) “double” keeled appearance to the area in the vicinity of the acutely angled periphery, pinkish inner laminar nacreous layer, extremely thin (transparent) outer prismatic layer with colour pattern of brown axial markings confined to the upper half of each whorl.

The number of spiral cords on the base is the character that varies most intraspecifically; four of the shells having a narrow smooth central zone whereas, in two others (WAM S14251 and S14252b), spiral cords cover the entire base (18 and 19 respectively). This character varies independently of location, but another character (spire angle) apparently varies geographically. Shells from the north of the range have a relatively narrow spire angle ( $69^{\circ}$  to  $72^{\circ}$ ) that does not change with age (Fig. 1A–D), whereas those from the west of the range have a relatively broader spire angle ( $82^{\circ}$ ) resulting from the last adult whorl expanding more rapidly than previous whorls to give a cocloconid profile overall (Fig. 1E,F).

*Calliostoma bellatrix* clearly belongs in the subgenus *Anpullostrochms* Monterosato (*sensu* Marshall 1995b) because of its narrowly conical shell, acutely angled periphery, lack of umbilicus, P1–P3 commencing on the first teleoconch whorl, and the strongly flattened and strongly nodulose early teleoconch whorls that bear strong interconnecting axial costae. Three species in

that subgenus appear closest to *C. bellatrix* conchologically – *C. schroederi* Clench and Aguayo, *C. iris* Kuroda and Habe, and *C. heros* Marshall. Most similar, perhaps the Caribbean counterpart (cognate) species of *C. bellatrix*, is *C. schroederi* Clench and Aguayo, 1938 from 320 to 460 metres depth off the Bahamas and Cuba. That species was redescribed by Clench and Turner (1960) and placed in the subgenus *Kombologion*. It appears uniformly silvery nacreous but is ivory white, with 4 to 5, thread-like, yellow bands above and below the periphery (pinkish nacreous and axially flamed or blotched in *C. bellatrix*), the periphery is less acutely angulate so the aperture is more circular, there is a weaker cord (?S2) between P3 and S3 on the body whorl and the base is smooth except for a few fine spiral threads around the columellar area. The shell of *C. iris*, which is known from 150 to 250 m depth off southern Japan, is more narrowly conical (mean spire angle  $52^{\circ}$ ), with relatively strong strong spiral cords in the central section of the later teleoconch whorls (smooth in *C. bellatrix*), and strong and regular brown maculations on the periphery signifying the maximum development of the axial lines (markings confined to the upper half of the whorls in *C. bellatrix*). The shell of *C. heros*, from 255 to 425 m off the Loyalty Islands, has a narrow umbilicus, P3 is maculated with yellowish brown and white, and there are numerous spiral cords on all the spire whorls as well as the base.

*Calliostoma (Bathyfautor) coriolis* Marshall, from 630 to 705 metres off Chesterfield Reef and Lansdowne Bank, is superficially similar to *C. bellatrix* in having an acute “double” peripheral keel and obsolete spiral sculpture on the central sections of its teleoconch whorls. However this keel is actually composed of S3 plus P4 (P3 plus S3 in *C. bellatrix*) and the shell is more narrowly conical (mean spire angle  $56^{\circ}$ ), uniformly white, and very narrowly umbilicate.

**Etymology.** The specific name recalls the bright star Bellatrix in the constellation of Orion, the Great Hunter. The specific name is intended as a noun in apposition to the generic name and so is indeclinable.

## ACKNOWLEDGMENTS

I am very grateful to George Checseman for donating samples of the molluscs and crustaceans caught as bycatch in scampi trawls to the Museum and Art Gallery of the Northern Territory. Bruce Marshall kindly assisted with pertinent literature, offered constructive comment on a first draft of this paper and supplied specimens for study. Additional specimens came courtesy of Shirley Slack-Smith. Peter Davic provided identifications for the crustaceans.



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Accepted 29 October 2002



## A new species of *Palaemonella* (Crustacea: Decapoda: Pontoniinae) from East Africa

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### ABSTRACT

A new species of pontoniine shrimp, *Palaemonella maziwi* sp. nov., from East Africa, is designated, having been previously misidentified with *P. spinulata* Yokoya, 1936. Further morphological details are noted and illustrated. Literature records of *Palaemonella spinulata* from the western Indian Ocean are erroneous.

KEYWORDS: *Palaemonella maziwi* sp. nov., Crustacea, Decapoda, Palaemonidae, Pontoniinae, Tanganyika, Kenya.

### INTRODUCTION

The recent study of some shrimp specimens from Western Australia, identified as *Palaemonella spinulata* Yokoya, 1936, led to the re-examination of some East African specimens previously reported under this name. The Australian specimens are clearly not conspecific. The East African specimens present a number of small but distinctive characters that distinguish them from the Western Australian specimens, which agree closely with Yokoya's original description and illustrations. The East African specimens are here given a new species name. The major features of the new species are noted and illustrated in Bruce (1975). There are now no confirmed records of *Palaemonella spinulata* Yokoya from the western Indian Ocean.

Abbreviations used: CL, post-orbital carapace length. NTM, Northern Territory Museum, Darwin. RMNH, Nationaal Natuurhistorisch Museum, Leiden.

### SYSTEMATICS

#### *Palaemonella maziwi* sp. nov.

(Fig. 1A–H)

*Palaemonella spinulata* - Bruce, 1975: 177–183, figs 6–7. - Bruce, 1978: 209, fig. 1. Not *Palaemonella spinulata* Yokoya, 1936: 135–136, fig. 4.

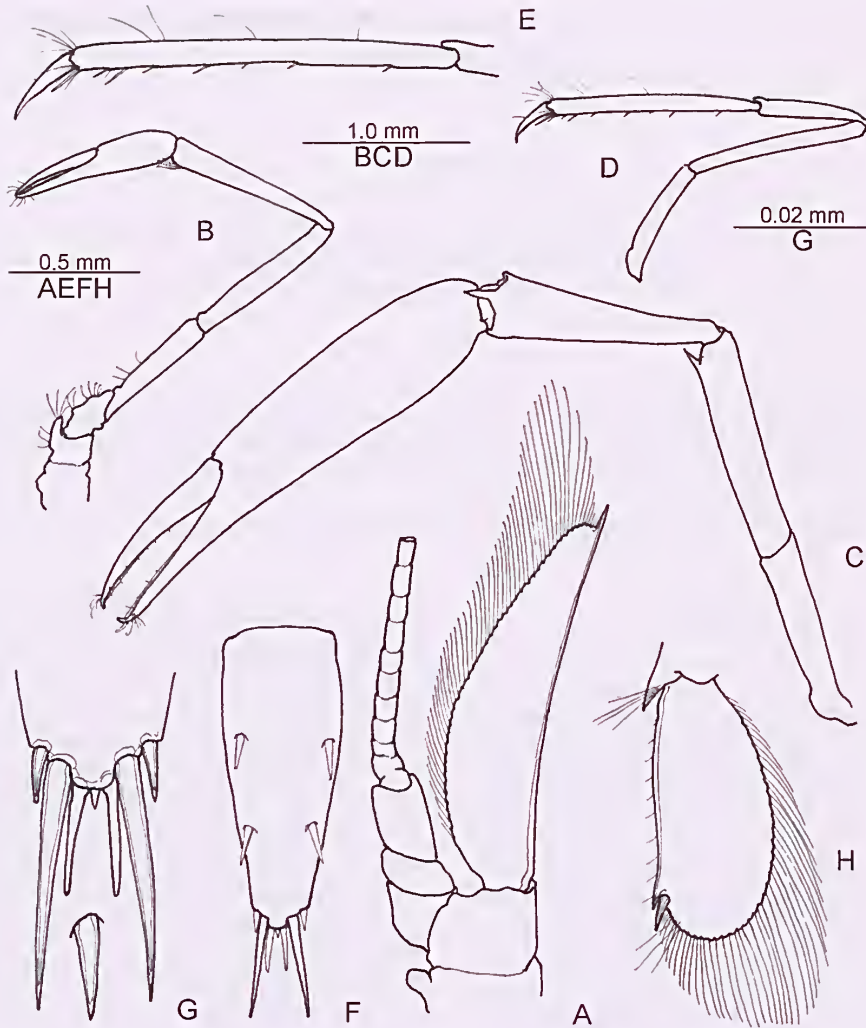
**Material examined.** HOLOTYPE - ♂, Maziwi Island, Pangani, Tanganyika, stn AJB-97, 5° 30.6' S, 39° 04.06'E, #1297, 2 m, reef edge, coll. A.J. Bruce, 12 December 1970, NTM Cr.013369. PARATYPES - 1♂, 1 ovigerous ♀, Ras Iwatine, Bamburi, Mombasa, Kenya, stn AJB-101, 4°00.75'S, 39° 00.43'E, #1357, 0.5–1.0 m, lagoon, coll. A.J. Bruce, 13 January 1971, NTM Cr.013370; 1♀, Fort Jesus, Mombasa, Kenya,

stn AJB-205, #2185, coll. J. Wood, scuba, 10 m, 21 August 1974, RMNH D.50023.

**Diagnosis.** A small shrimp; rostrum short, reaching to about middle of intermediate segment of antennular peduncle, much shorter than scaphocerite, 0.85 of CL, dentition 1+5–6/1–2; supraorbital ridges absent, spines present, large; hepatic spine small, inferior orbital angle feebly produced; fourth and fifth pleura posteroventrally blunt and acute respectively; mandible with 1-segmented palp; fourth thoracic sternite with slender median process; second pereopods with carpus with large slender acute terminal distolateral tooth, merus with well developed distoventral tooth, ischium unarmed; ambulatory pereopods with dactyls short, about 0.53 of propod length, ventrally biconcave; propod with long distoventral spines, numerous similar ventral spines; male second pleopod with endopod reduced, not exceeding appendix interna.

**Description.** The principal features of *P. maziwi* sp. nov. are noted and illustrated in Bruce (1978). These may be augmented by the following notes on the holotype specimen. The antennal peduncle presents no special feature: the fused portion of the upper rami consists of 6 segments, the shorter free ramus of a single segment, with 6 groups of aesthetascs; lower flagellum short, with about 8 segments only. The scaphocerite (Fig. 1A) is about 4 times longer than its greatest width, at about 0.3 of its length, tapering strongly distally, lateral margin concave, with well developed distal tooth far exceeding lamella. Cornea globular, diameter about 0.3 of CL, without dark transverse bars. Second maxilliped with small subrectangular epipod, with minute tubercular podobranch vestige. Third maxilliped normal, with subcircular lateral plate, without discernible arthrobranch. First pereopod (Fig. 1B)





**Fig. 1.** *Palaemonella maziwi* sp. nov. male, holotype, Maziwi Island, Kenya, NTM Cr.013369. A, scaphocerite; B, first pereiopod; C, right second pereiopod, dorsal aspect; D, third pereiopod; E, same, propod and dactyl; F, telson; G, posterior telson spines, dorsal spine inset; H, uropod, exopod.

slender, fingers about 1.2 times palm length, slender, with minute hooked tips, cutting edges entire; carpus slightly longer than chela, also slightly longer than merus, ischium 0.75 of carpus length, coxa with small ventral process. Second pereiopod (Fig. 1C) as previously described, chela about 1.8 of CL, fingers 0.6 of palm length, palm 3.2 times longer than greatest width, carpus 0.72 of palm length, subequal to meral length, 1.16 times ischial length. Third pereiopod (Fig. 1D) slender, dactylus as previously described, about 0.23 of propod length, propod (Fig. 1E) about 16 times longer than width, 0.75 of CL, with long distoventral spine, about 0.4 of dactyl length, 7 shorter ventral spines of reducing size proximally. Fourth pleuron bluntly subrectangular, fifth slightly produced, acute.

Telson (Fig. 1F) 2.5 times longer than basal width, with 2 pairs of large dorsal spines at about 0.33 and 0.66 of length, spines about 0.14 of telson length, posterior margin angular with small acute median process, lateral spines about half length of dorsal spines, intermediate spines 0.33 of telson length, twice length of subventral non-sctulose submedian spines (Fig. 1G). Uropod with protopod posterolaterally acute, sctose; exopod (Fig. 1H) broad, 2.3 times longer than width, lateral margin with robust distal spine, about 0.14 of exopod length, similar to dorsal telson spines, with large acute tooth proximally.

**Measurements (mm).** Holotype male: CL, 1.6 ; carapace and rostrum, 2.9; total body length, approx., 7.4; second pereiopod chela, 3.0.



**Etymology.** Named after the locality of capture of the holotype, Maziwi Island, Tanganyika, an island which no longer exists. Etymology unknown, used as a noun in apposition.

**Systematic position.** Only three species of *Palaemonella* from the Indo-west Pacific region are known to have distinct supraorbital spines; *P. crosnieri* Bruce, 1978, *P. spinulata* and *P. maziwi* sp. nov.. *Palaemonella crosnieri* is immediately distinguished from all other species of the genus by the presence on the ischium of the second pereopods of a well developed distoventral tooth.

*Palaemonella maziwi* sp. nov. may be distinguished from *P. spinulata* Yokoya, the most closely related species with which it was previously confused, by the following characters:

- (1) smaller size, CL to 2.2 mm;
- (2) rostrum not reaching to proximal end of distal segment of antennular peduncle;
- (3) dentition 1 + 5–6/1–2;
- (4) supraorbital spine large, hepatic spine small;
- (5) inferior orbital angle not produced;
- (6) mandibular palp single segmented;
- (7) second pereopod carpus with long slender acute distolateral tooth;
- (8) ambulatory dactyl ventrally biconcave;
- (9) male second pleopod with endopod reduced, not exceeding appendix interna.

**Remarks.** The specimens referred to *Palaemonella spinulata* Yokoya by Bruce (1975), from Tanganyika and Kenya, are now not considered to belong to that species and are here described as a new species. The type material of *P. spinulata* Yokoya has long been considered as lost (Bruce 1970). The genus *Palaemonella* Dana has been recently reviewed (Bruce 2002) and the information on *P. spinulata* should be revised in the light of the above findings. The species is not now known with certainty to occur in the western Indian Ocean but has been reported from northern Australian waters, Western Australia, Northern Territory and Queensland (Davie 2002; Bruce 2002); Hainan Island, China (Li 2001), and Agrihan Island, Marianas Islands (Hayashi *et al.* 1994), as well as the type locality, Misaki, Japan.

The male holotype from Maziwi Island had a small single segmented mandibular palp showing feeble signs of subdivision into two segments.

The specimens of *Palaemonella spinulata* reported from 40 metres depth on Reunion (Bruce 1978) may also belong to *P. maziwi* sp. nov. but are not available for re-examination. The juvenile, CL 1.0; rostral dentition 4/0, has a particularly large supraorbital spine and lacks an hepatic spine.

**Distribution.** Known only from the type locality, Maziwi (Island) reef, Tanzania, and Ras Iwatine and Fort Jesus, Kenya (Bruce 1975). The mention of a specimen from Kisiti Island, Kenya, in Bruce (1978: 209) is erroneous.

## ACKNOWLEDGEMENT

This study was carried out with the support of the Australian Biological Resources Study.

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Accepted 14 November 2002





## Ascidacea (Tunicata) from Darwin, Northern Territory, Australia

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### ABSTRACT

Forty species of ascidians from the Northern Territory (mostly from Darwin Harbour) are discussed. These include three new species (*Clavelina amplexa* sp. nov., *Distaplia cuspidis* sp. nov. and *Leptoclinides complexus* sp. nov.). All the species discussed below are colonial and over one half are in the family Didemnidae, suggesting that the prolific replication resulting in exponential rates of colony growth, flexibility in form and viviparous habit displayed by these organisms may be a selective advantage in the tropics. These also may be factors contributing to the tropical diversity reflected in this collection from the northern coast of Australia which, separated from Indonesia and the islands to the north only by the Timor Sea, is in the centre of the Indo-west Pacific tropical region.

KEYWORDS: Ascidacea, Tunicata, Didemnidae, Darwin Harbour, northern Australia, new species, tropical diversity, ovoviviparous, colonial, replication, Indo-west Pacific.

### INTRODUCTION

The class Ascidacea, sessile organisms of the subphylum Tunicata (Protochordata), are a conspicuous part of the filter-feeding component of benthic marine invertebrate communities. Ascidians strain micro-organisms and organic particles from vast quantities of water driven through their large pharynges by the cilia lining the pharyngeal perforations. Although both solitary and colonial species are fixed to the substrate throughout their adult lives, their tailed, free swimming larvae ensure recruitment, gene flow and site selection.

Although comprehensive treatments of the Ascidacea are presented by Kott (1985; 1990a,b; 1992a,b; 2001), examination of additional material is revealing further diversity in this class of the Tunicata which abounds around the Australian continent and in the tropical Indo-west Pacific. Some recent accounts of tropical western Pacific species, have been revised in the light of this additional material, some misconceptions have been corrected and some synonymy is resolved. The fact that northern Australia is part of the Indo-west Pacific tropical area is emphasised by these records and the biodiversity of its marine fauna is reflected in the growing catalogue of species recorded.

All of the 40 species discussed here are colonial (over half are in the family Didemnidae), with similar colony organisation and small zooids associated with prolific replication, rapid exponential growth rates, flexibility in growth form and a viviparous habit. These

strategies appear to be selective advantages in tropical waters and contribute to tropical species diversity (see Kott 2001).

Darwin Harbour, one of the most northerly locations of the Australian continent and well north of the Tropic of Capricorn, is separated from Timor and the Sunda Islands of Indonesia only by the Timor Sea and its longitude is in the centre of the Indo-west Pacific tropical region. It might be expected to act as a refuge for species of both the north-eastern and north-western Australian coasts as well as Indonesian species and may play a significant role in gene flow and recruitment of tropical species into Australian waters. Up to the present time, however, it has not been a well-collected location for the Ascidacea. Previously only 21 species were recorded from Darwin and 28 from other parts of the Northern Territory (including eight recorded also from Darwin). Species diversity in Darwin Harbour could also be expected to be enhanced by the maritime activity in these ports, including the provision of a diversity of substrates and habitats represented by harbour installations such as vertical wharf piles.

The following account is based mainly on collections made (by SCUBA) at five locations (off East Point, Iron Ore Jetty, Mandorah Jetty, Plater Rock, reef off Charles Point) in Darwin Harbour (Fig. 1) by Karen Gowlett Holmes, and of the 40 species discussed, 38 are from this collection. The other two species are from Port Essington and the Gulf of Carpentaria. Two new species are described from the Darwin Harbour collection, and one is from Port Essington. The majority

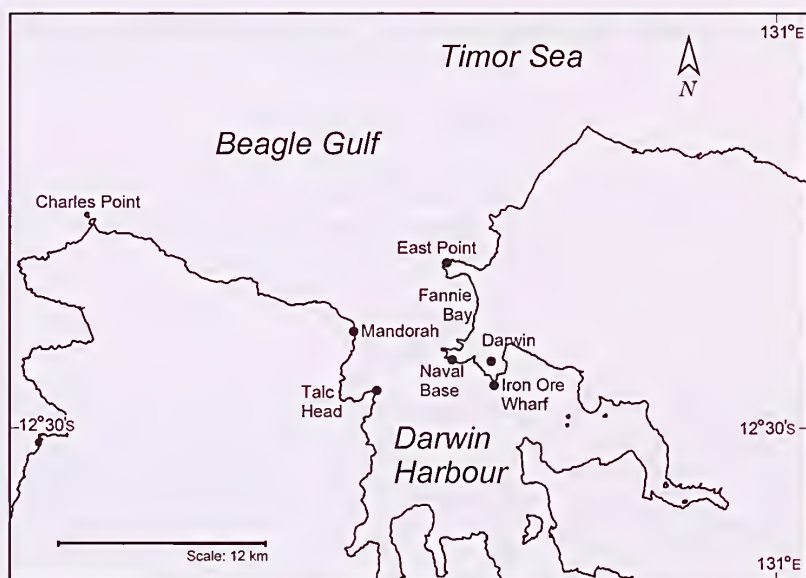


Fig. 1. Darwin Harbour, showing collecting locations.

of the species are newly recorded from Darwin, only nine having been recorded previously, viz. *Clavelina oliva* Kott, 1990a, *Pycnoclavella diminuta* (Kott, 1957), *Hypodistoma deerratum* (Sluiter, 1895), *Sycozoa seiziwadai* Tokioka, 1952, *Trididemnum savignii* (Herdman, 1886), *Didemnum clavum* Kott, 2001, *D. molle* (Herdman, 1886), *Diplosoma virens* (Hartmeyer, 1909) and *Aplidium multiplicatum* Sluiter, 1909, and are also known from other tropical Australian locations. Six species – *Distaplia mikropnoa* Sluiter, 1909, *Polysyncratoron pavementum* Monniot, 1993, *Trididemnum marmoratum* (Sluiter, 1909), *T. planum* Sluiter, 1909, *Didemnum madeleineae* Monniot and Monniot, 2001 and *D. parau* Monniot and Monniot, 1987 – are newly recorded from Australia. The species list for Darwin has been increased from 21 to 49 and that for the Northern Territory generally (including Darwin) from 41 to 70. Forty of the species now known to occur in Darwin have a range that includes Indonesia and/or other parts of the western Pacific. Despite the fact that the majority of species known from the Northern Territory are those recorded from Darwin, this new sampling has taken only 12 of the 41 species formerly recorded from the Northern Territory, and only few of the newly recorded species were taken more than once. These figures demonstrate how poorly the Northern Territory and Darwin ascidian fauna is known.

#### Species recorded from Darwin

\*Species recorded only in previously published works (see Kott 1985, 1990a, 1992a, 2001).

\*\*Species newly recorded from Darwin but not discussed in this work.

Note: formal page citations for new species are indicated below, although they may be referred to informally in prior pages.

#### Clavelinidae Forbes, 1848

*Clavelina amplexa* sp. nov. (p. 21)

*Clavelina oliva* Kott, 1990a

*Nephtheis fascicularis* (Drasche, 1882)\*

#### Pycnoclavellidae Kott, 1990a

*Pycnoclavella diminuta* (Kott, 1957)

#### Holozoidae Berrill, 1950

*Distaplia cuspidis* sp. nov. (p. 23)

*Distaplia mikropnoa* (Sluiter, 1909)

*Distaplia regina* Kott, 1990a

*Sycozoa seiziwadai* Tokioka, 1952

*Hypodistoma deerratum* (Sluiter, 1895)

#### Polycitoridae Michaelsen, 1904

*Polycitor circes* Michaelsen, 1930

*Eudistoma eboreum* Kott, 1990a

*Eudistoma superlatum* Kott, 1990a

*Cystodytes philippinensis* (Herdman, 1886)

#### Polyclinidae Milne Edwards, 1841

*Synoicum macroglossum* Hartmeyer, 1919

*Aplidium grisiatum* Kott, 1998

*Aplidium altarium* (Sluiter, 1909)\*

*Aplidium multiplicatum* Sluiter, 1909

#### Didemnidae Giard, 1872

*Leptoclinides aciculus* Kott, 2001

*Polysyncratoron arafurensis* Tokioka, 1952

*Polysyncratoron cuculliferum* (Sluiter, 1909)

*Polysyncratoron dromide* Kott, 2001



*Polysyncraton pavimentum* Monniot, 1993  
*Polysyncraton pseudorugosum* Monniot, 1993  
*Polysyncraton purou* Monniot and Monniot, 1987  
*Didemnum clavum* Kott, 2001  
*Didemnum granulatum* Tokioka, 1954  
*Didemnum madeleineae* Monniot and Monniot, 2001  
*Didemnum membranaceum* Sluiter, 1909  
*Didemnum molle* (Herdman, 1886)  
*Didemnum parau* Monniot and Monniot, 1987  
*Didemnum perplexum* Kott, 2001  
*Didemnum psammotode* (Sluiter, 1895)  
*Trididemnum cyclops* Michaelsen, 1921\*  
*Trididemnum planum* Sluiter, 1909  
*Trididemnum savignii* (Herdman, 1886)  
*Trididemnum sibogae* (Hartmeyer, 1910)  
*Lissoclinum badium* Monniot and Monniot, 1996  
*Lissoclinum bistratum* (Sluiter, 1905a)\*  
*Lissoclinum conchylum* Kott, 2001  
*Lissoclinum durable* Kott, 2001  
*Lissoclinum badium* Monniot and Monniot, 1996  
*Lissoclinum limosum* Kott, 2001  
*Lissoclinum multifidum* (Sluiter, 1909)  
*Diplosoma translucidum* (Hartmeyer, 1909)  
*Diplosoma virens* (Hartmeyer, 1909)

Ascididae Adams and Adams, 1858  
*Ascidia capillata* Sluiter, 1887\*  
*Ascidia sydneyensis* Stimpson, 1855\*  
*Phallusia millari* Kott, 1985\*\*

Perophoridae Giard, 1872  
*Ecteinascidia diaphanis* Sluiter, 1885\*

Styelidae Sluiter, 1895  
*Cnemidocarpa areolata* (Heller, 1878)\*  
*Polycarpa papillata* (Sluiter, 1885)\*

Pyuridae Hartmeyer, 1908  
*Microcosmus exasperatus* Heller, 1878\*

In addition to species newly recorded from Darwin, *Leptoclinides complexus* sp. nov. (p. 30) from Port Essington and *Trididemnum marmoratum* (Sluiter, 1909) from the Gulf of Carpentaria are discussed below.

## METHODS

Material referred to by a museum registration number has been examined in connection with this work. A museum registration number of part of a colony is in italics immediately following the number of the colony sampled. Museums are referred to by the following abbreviations: AM, Australian Museum, Sydney; AIMS, Australian Institute of Marine Sciences, Townsville; NTM, Museum and Art Gallery of the Northern Territory, Darwin; QM, Queensland Museum, Brisbane; ZMA, Zoological Museum University of

Amsterdam, The Netherlands; ZMH, Zoological Museum, University of Hamburg, Germany.

Methods used to examine material, conventions used in describing it and discussions on definitions and relationships of genera, families and higher level taxa are set out in the relevant volume of the Australian Ascidacea (Kott 1985, 1990a, 1992a, 2001).

In this and all previous works by the present author, the number of stigmata per row is the number between the dorsal and ventral midlines on one side of the pharynx only.

The month that larvae were found in the colonies is recorded to contribute data on breeding seasons.

## TAXONOMY

### Family Clavelinidae

#### *Clavelina amplexa* sp. nov.

(Figs 2A–C, 21A,B)

? *Clavelina robusta* - Kott, 1990a: 242, pl. 4g.

Not *Clavelina robusta* Kott, 1990a: 61.

**Records.** *Type locality:* Northern Territory, Darwin, off East Point, 6–8 m, coll. K. Gowlett Holmes, 19 September 1999, holotype NTM E155; reef off Charles Point, 6–8 m, coll. K. Gowlett Holmes, 16 July 2001, paratype NTM E208. *Further records:* Mandorah Jetty, NTM E218. *Previously recorded* (see Kott 1990a): ? Western Australia (Port Hedland).

**Description.** The newly recorded specimens are translucent with a broad opaque creamish-yellow triangular patch each side of the antero-dorsal midline, the apex of each triangle projecting in between the apertures, and the base drawn out around the atrial siphon, sometimes continuous behind it but often interrupted across the dorsum behind the aperture (Figs 21A,B). The pigment is not in the actual rim of the apertures. Lines or broader flashes of the same colour often extend down the dorsal and ventral midlines. Zooids are up to 2 cm long and branch off a common basal stalk. They are blue in preservative. Muscles are arranged according to the formula 7E, 5B, 3D (see Kott 1990a). The branchial sac is broad with about 20 rows of 20 to 30 stigmata. The anal border has a fringe of short papillae around the rim. Embryos are crowded in a brood pouch on the right side of the top of the oesophageal neck where development begins. It proceeds as embryos move up into the thorax and across the posterior end of the right side of the thorax to its ventral margin where they are liberated from the oviduct into the atrial cavity.

Larvae (present in the holotype and the paratype) have a 1 mm long trunk and a relatively short tail barely reaching to the anterior end of the trunk. Five rows of

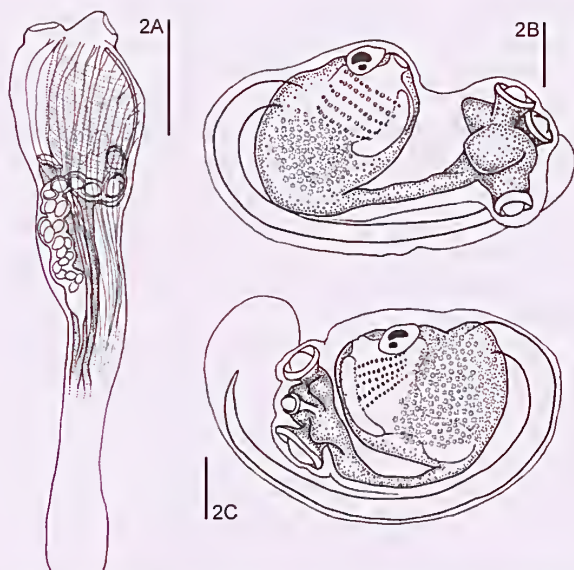


Fig. 2. *Clavelina amplexa* sp. nov.: A, zooid (NTM E155 holotype); B, larva (NTM E155 holotype); C, larva (NTM E208 paratype). Scale bars: A, 5.0 mm; B, C, 0.2 mm.

up to 17 short stigmata are in the oozoid. The tail fin is particularly broad terminally. The triradially arranged adhesive organs are on a flattened frontal plate connected to the postero-ventral part of the trunk by a long, narrow stalk and a broad ampulla projects from the plate at the base of each adhesive organ.

**Remarks.** *Clavelina robusta* Monniot and Monniot, 1996 and 2001, and *Clavelina* sp. *sensu* Monniot and Monniot, 1996 have a complete band of colour around the margin of each zooid opening as described for Philippine specimens of *C. robusta* (QM G12757; Kott 1990a). The colour pattern in the present species, which lacks the continuous band of pigment found in the rim of the apertures in *C. robusta*, resembles the photographed specimens from Port Hedland questionably assigned to *C. robusta* by Kott (1990a). As well as the colour pattern, significant differences that can be detected between the present species and *C. robusta* are the less robust zooids with fewer stigmata (about 20 per row, but up to 60 in *C. robusta*) and a slightly shorter larval trunk and longer stalk connecting the frontal plate to the oozoid. The colour pattern in this species resembles that in some colonies of *Clavelina arafurensis* (see Kott 1990a, pl. 1f), although the latter species is clearly distinguished by its embedded zooids.

The large expanded terminal tail fin appears to be present in most these large clavelinid larvae although it has not been described previously (see Kott 1990a).

The species name is from the Latin *amplexus*, and refers to the colour band encircling the apertures.

### *Clavelina oliva* Kott, 1990

(Fig. 21C)

*Clavelina oliva* Kott, 1990a: 55.

**Records.** *New records:* Northern Territory (Darwin, Plater Rock, NTM E176). *Previously recorded* (see Kott 1990a): Western Australia (Shark Bay, Dampier Archipelago, Houtman Abrolhos), Queensland (Lindeman Island), Northern Territory (Darwin), Philippines.

**Description.** The *in situ* photograph (Fig. 21C) of the newly recorded specimens shows the small zooids projecting up through the sediments with a thick white band crossing the dorsum between the two apertures and with a median vertical white mark over the anterior end of the endostyle tapering posteriorly. The zooids are otherwise translucent. The colour appears to be variable, Kott (1990a) reporting white, yellow or green bands around the siphons, sometimes extending down the dorsum and with freckles of the same colour on other parts of the thorax.

The newly recorded specimens are relatively small (to 2 cm long) contracted zooids, a few joined basally. Thoracic muscles are arranged according to the formula for this species, viz. 8E, 3B, 3D (see Kott 1990a).

**Remarks.** Zooids resemble *Clavelina fecunda*, although the latter species has shorter zooids and the abdomina embedded in the basal test; and *Clavelina robusta* (with longer zooids in branching stalks, and shorter vascular stolons).

### Family Pycnoclavellidae

#### *Pycnoclavella diminuta* (Kott, 1957)

(Fig. 21D)

*Clavelina diminuta* Kott, 1957: 89.

*Pycnoclavella diminuta* - Kott 1990a: 73 and synonymy.

*Archidistoma diminutum* - Monniot 1997: 195.

?*Archidistoma dublum* Monniot, 1997: 196.

**Records.** *New records:* Northern Territory (Darwin, Plater Rock, NTM E177). *Previously recorded* (see Kott 1990a): Western Australia (Exmouth Gulf to Rottnest Island), Great Australian Bight, Lord Howe Island; Queensland (Heron Island to Lizard Island), Northern Territory (Darwin), Philippines.

**Description.** The species is characterised by its three rows of up to 100 stigmata, the anterior and posterior rows (respectively) deflected anteriorly and posteriorly along the mid-line, brown vesicles in the test of the stalks, a cluster of testis follicles in the loop of the gut, larvae with two tubular adhesive organs and an otolith as well as an ocellus, and a developmental sequence of a variable number of embryos in the oviduct. Embryos begin their development at the base of the abdomen.



**Remarks.** *Archidistoma dublum* Monniot, 1997 from Mozambique, sympatric with specimens assigned to *P. diminuta*, and differing from it only in being twice the size, may be a junior synonym of this highly variable species.

The tubular larval adhesive organs, fertilisation at the base of the oviduct, long oesophageal neek, smooth apertures, and small testis are all characteristics of *Pycnoclavella* (see Kott 1990a; in press).

# **Family Holozoidae**

## ***Distaplia cuspidis* sp. nov.**

(Figs 3A, B, 21E, F)

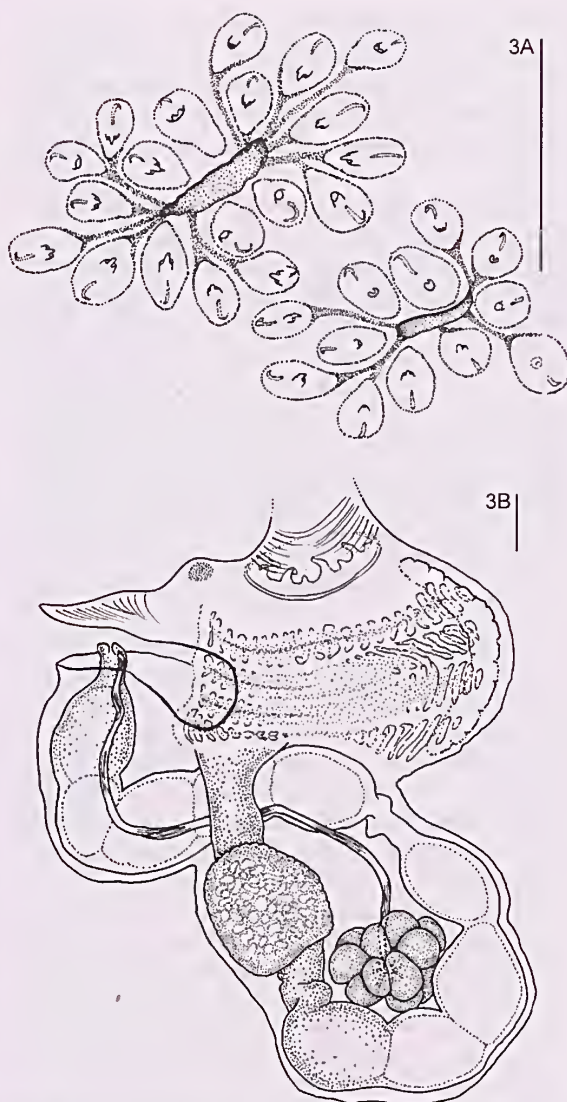
*Distaplia regina* - Monniot and Monniot 1996: 216.

Not *Distaplia regina* - Kott 1990a: 125. - Monniot and Monniot 2001: 257.

**Records.** *Type locality:* Northern Territory, Darwin, Plater Rock, 8–10 m, coll. K. Gowlett Holmes 21 September 1999, holotype NTM E171; 6–8 m, coll. K. Gowlett Holmes, 15 July 2001, paratype NTM E198). *Previously recorded* (see Monniot and Monniot 1996): Palau Islands.

**Description.** The colonies are translucent in preservative, but yellow-cream colour in life. Zooids are arranged in crowded circular to elongate systems in an irregular sponge-like encrusting colony. The surface of the colony often is depressed over each system. Many common cloacal openings are conspicuous, protuberant, circular openings with lobes accommodating the atrial lips, which appear to be white and clearly show through the test. However, sometimes the common cloacal apertures are long, open troughs overlapped along each side by a straight rim of test, and with atrial openings in a groove beneath this rim. Also, in some photographs there appear to be one or more pointed projections from the branchial and common cloacal apertures on the surface of the colony which, with the protuberant apertures, make it look spiky.

Zooids have large, almost spherical thoraxes with fine longitudinal thoracic museles and four rows of about 25 stigmata. The long stigmata lie regularly parallel to one and although parastigmatic vessels were not detected, fine vessels may once have been present holding the stigmata in place. The atrial aperture has a large pointed anterior lip and a smaller pointed posterior lip. Only about six short branchial tentacles alternate with rudimentary ones. The gut loop is vertical, and a cluster of male follicles is enclosed in the loop. The stomach wall has what appear to be crowded circular concavities in the inner lining. The rectum makes a right-angle bend to cross the oesophagus.



**Fig. 3.** *Distaplia cuspidis* sp. nov. (NTM E171, holotype): A, colony; B, zooid. Scale bars: A, 5.0mm; B, 0.2 mm.

**Remarks.** *Distaplia regina* Kott, 1990a, *D. racemosa* Kott, 1990a and the present new species have gonads in the gut loop, circular systems, an even external stomach wall without longitudinal folds or ridges and similar zooids with about the same number of stigmata. *Distaplia racemosa* systems are smaller, regularly circular, evenly spaced and well separated from one another, its thoracic muscles are predominantly transverse (crossing the endostyle) and the stomach lining does not have the distinct circular areolations of either *D. regina* or the present species. *Distaplia regina* is distinguished by its deep blue colour in life, dark red pigment cells in the test that persist in the preserved specimens, fewer stigmata, short irregular ridges that

form a reticular pattern in the stomach lining (rather than crowded circular concavities), a narrow gut loop with gonads protruding from the side of the zooid, fewer testis follicles and a smooth surface without protruding common cloacal apertures or branchial lobes.

*Distaplia regina sensu* Monniot and Monniot (1996) from the Palau Islands is identical with the present specimen. *Distaplia regina sensu* Monniot and Monniot (2001), also from the Palau Islands, has a right angle bend in the rectum, a circular pattern in the stomach wall and numerous male follicles in a grape-like cluster in the gut loop like the present species. However, it is said to have club-shaped or cushion-like colonies with the zooids in lines converging at the top of the colony like the cloacal systems in *D. mikropnoa*. Thus *D. regina* – Monniot and Monniot (2001) does not appear to be conspecific with either *D. mikropnoa* or the present species and is distinguished from *D. regina* Kott (1990a) by its cluster of numerous testis follicles and a different colony.

*Distaplia cuspidis* is most consistent in its zooids and colony as evidenced by photographs of specimens from Darwin and the Palau Islands (Monniot and Monniot 1996: pl. 7a). It is distinguished by its soft spongy test, projecting cloacal apertures and branchial lobes, pink/beige colour, circular pattern of apparent concavities in the stomach wall, wide loop of the post-pyloric part of the gut loop and right angle bend of the rectum to completely enclose the gonads.

The species name is from the Latin “cuspid”, the point or the head of a spear. It refers to the points on the surface of the colony surrounding the apertures.

#### *Distaplia mikropnoa* (Sluiter, 1909)

(Figs 4A–C, 21G,H)

*Polyclinum mikropnous* Sluiter, 1909: 94

*Distaplia mikropnoa* - Tokioka 1955: 51. - Tokioka 1967: 129. - Monniot and Monniot 2001: 256.

**Records.** *New records:* Northern Territory (Darwin, Plater Rock, NTM E199, E200). *Previously recorded* (see Tokioka 1955, 1967; Monniot and Monniot 2001; Sluiter 1909): Palau Islands, Indonesia.

**Description.** The newly recorded specimen is a large (maximum width 35 mm, 40 mm high) flattened cone (the head of colony) with the fleshy stalk removed from its asymmetrical point of attachment at one side of the base of the colony. Zooids are in about 30 double rows, converging from the wide base to the top of the head. The head is a translucent creamish colour and a pink colour resulting from faecal pellets in the rectum. The pink spot associated with the neural ganglion (Monniot and Monniot 2001) was not detected. About 20–25 stigmata per row are in the branchial sac. Parastigmatic vessels were not detected, nevertheless, the long parallel stigmata are in place despite distortion

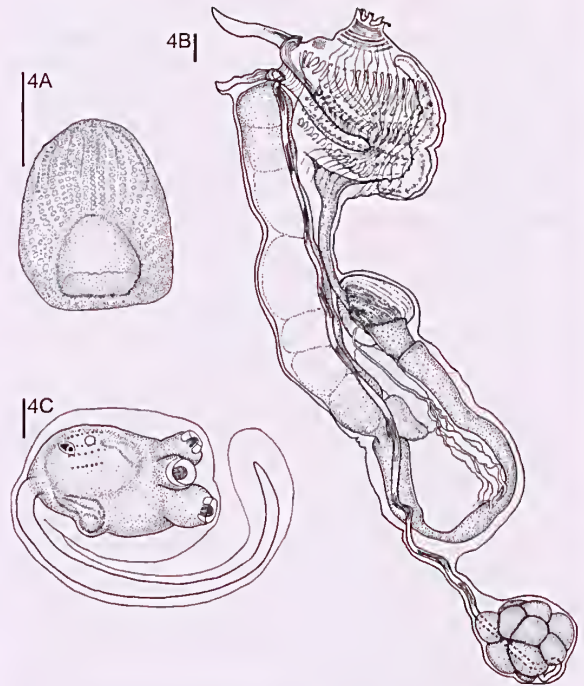


Fig. 4. *Distaplia mikropnoa* (NTM E199): A, colony; B, zooid; C, larva. Scale bars: A, 2.0 cm; B,C, 0.2 mm.

of the thoraces. Several of the most dorsal of up to 20 longitudinal thoracic muscles divert out around the large anterior atrial lip and the posterior rim of the atrial opening also projects out in a lip. The stomach has about 20 fine, parallel longitudinal ridges that appear to protect slightly from both the internal and external surface. The oesophagus is longer than has been reported previously, the stomach being nearly half way down the descending limb of the long vertical gut loop. The duodenal region is short, opening into a slightly wider mid-intestine through a distinct valve. There is no posterior stomach, the even, tubular mid-intestine continuing around the pole of the loop and abruptly entering the rectum a short distance up the ascending limb of the loop. No distinct reservoir of the gastrointestinal gland was detected in this specimen. Relics of the epicardial sacs (see Tokioka 1967: fig. 46e) are evident in some (but not all) zooids, a system of branched ducts are present in the gut loop along the descending (proximal) part of the mid-intestine and a flap of tissue attached to the ascending (distal) part of the mid-intestine curves around its inner wall. Clumped testis follicles and an ovary are in the gonad sac attached to the zooid by a long narrow ligament containing the gonoducts. The flap-like organ – which Tokioka (1967) thought might be a circumintestinal gland – always is present in the vicinity of the mid-



intestinal junction with the rectum and appears to be the heart. It is not associated with the duct of the gastro-intestinal gland which extends vertically from the stomach down along the inside of the post-pyloric part of the descending limb of the gut loop, where it branches into many tubules.

A single embryo is incubated in a brood pouch projecting from the postero-dorsal corner of the thorax. The larval trunk is 1.0 mm long and the stalk is wound two-thirds of the way around it. The three triradially arranged adhesive organs have deep epidermal cups and thick bulbous stalks. The oozoid, near the posterior end of the trunk, has four rows of stigmata and the gut loop is tucked up horizontally behind the thorax. Larvae are present in July.

**Remarks.** The zooids, larvae and colony are like those formerly reported for this species, which previously has not been taken in Australian waters.

The disposition of the main duct of the gastro-intestinal gland which, in this species, does not cross from the stomach to the ascending limb of the gut loop but extends down the descending loop is unusual and may be associated with the longer than usual post-pyloric part of the narrow vertical gut loop.

The 'pyloric ampulla' referred to by Monniot and Monniot (2001) has no homologue in the Ascidacea unless it is the misplaced gastric reservoir (of the gastro-intestinal gland) found in other species of the Holozoidae. However such a reservoir has not been detected in the newly recorded specimens. The organ figured by Monniot and Monniot (2001: fig. 44A) is in the position of the heart but the nature and homology of ligaments or ducts-shown in the figure are not known and they have not been detected in the present specimens.

The lack of a posterior stomach and the long mid-intestine curving around in the pole of the gut loop are characters shared with other species of the Holozoidae and may be family characters additional to those discussed by Kott (1990a).

Kott (1990a) was mistaken in referring to an anastomosing network of stomach folds and a stalk as the characters distinguishing this species from *Distaplia stylifera*. The zooids of *D. stylifera* (including the longitudinally ridged stomach) are similar to those of the present species and both species have a similar fleshy stalk. The long double rows of zooids converging to terminal common cloacal apertures, long post-pyloric part of the gut loop, lack of a gastric reservoir and the course of the gastro-intestinal ducts distinguish the present species from *D. stylifera* (which has oval to elongate systems, common cloacal apertures all over the head, a short abdomen, a gastric vesicle and the gastro-intestinal gland extending from the stomach to the ascending limb of the gut loop).

## *Sycozoa seiziwadae* Tokioka, 1952

(Figs 22A–H)

*Sycozoa seiziwadae* Tokioka, 1952: 99.

*Sycozoa seiziwadae* - Kott 1990a: 152 and synonymy.

*Sycozoa cerebriformis* - Monniot and Monniot 2001: 259.

**Records.** *New records:* Northern Territory (Darwin, Plater Rock, NTM E161–2 E164 E219). *Previously recorded* (see Kott 1990a, Monniot and Monniot 2001): NW Australia (Cape Jaubert, Broome, Port Hedland, Dampier Archipelago, Cape Preston), NE Australia (Cronulla, Great Barrier Reef), Arafura Sea, New Caledonia, Philippines, Indonesia.

**Remarks.** Monniot and Monniot (2001) have compared the juvenile holotype colony of *Sycozoa cerebriformis* (Quoy and Gaimard, 1834) with newly recorded colonies of the present species from Indonesia. Without reference to the descriptions and discussions of Hartmeyer (1919), Michaelsen (1923, 1924), Tokioka (1952), Millar (1963, 1975) and Kott (1990a), all drawing attention to differences in the colony form of various *Sycozoa* spp., Monniot and Monniot (2001) argue that the present species is conspecific with *S. cerebriformis*. Although both species are fleshy with stalks that sometimes branch and heads that sometimes fuse, there are significant differences in colonies, zooids and larvae (see also Tokioka 1952, Kott 1990a).

*Sycozoa seiziwadae* is a tropical species with conical to fan-shaped heads, ovoid in transverse horizontal section, each on a terminal branch of the thick fleshy arborescent main stalk, with up to 16 double rows, each of 10–15 functional zooids, per head. As the colony grows, the number of branches, each with its terminal head, increases and adjacent heads usually fuse around their upper margins. However the heads remain inverted cones to fans and although their number increases neither their size nor their shape changes in any significant way. *Sycozoa cerebriformis* is a temperate species in which juvenile colonies have a fan-shaped head. With growth the head becomes a wide, flat, relatively narrow ribbon, sinuously folded and convoluted, its lower edge gathered into the top of a short, fleshy stalk, which only occasionally branches. Rarely the ribbon-like convoluted head may fuse with an adjacent head. With growth the heads increase in width and convolutions to form tight rosettes of ever increasing size and complexity. Kott (1990a) refers to one head that (if unfolded) would measure 74 cm, forming a convoluted rosette 8 cm in diameter. Only about eight functional zooids per row occupy the top 1 cm of each head, but the number of double row systems in one of these folded heads vastly exceeds the number in the relatively narrow conical to flat or only slightly curved heads of *S. seiziwadae*.

The zooids of *S. seiziwadaei* have 18–20 stigmata per row (up to 15 in the last two rows in *S. cerebriformis*). Larvae of *S. seiziwadaei* have a trunk 0.7 mm long with the tail wound almost completely around it (although the tail fin is longer) and what appears to be three small buds (Millar 1963; Monniot and Monniot 2001). The larval trunk of *S. cerebriformis* is 0.8–1.1 mm long with the tail wound more than once around it, the tail fin extending the encirclement to one and a quarter times around the trunk. Buds have not been detected in the larval trunk of *S. cerebriformis*. These differences in the zooids and larvae reinforce the more significant difference in the growth pattern and shape of the mature colonies, which, in addition to differences in the number of stigmata, Tokioka (1952) recognised as distinguishing the Arafura Sea specimens from other (well) known and well documented species of this genus including *Aplide cerebriforme* Quoy and Gaimard, 1834. Monniot and Monniot's concluding sentence (2001: 261) in their discussion of this species is both irrelevant and certainly untrue.

Monniot (1988) may have overlooked accounts of other species of this genus when she assigned New Caledonian specimens of the present species to the Antarctic species *Sycozoa sigillinoides*.

The white opaque material along the upper surface of some of the living colonies (NTM E164; Fig. 22A) was not detected in preserved specimens, in which the test is translucent.

### *Hypodistoma deerratum* Sluiter, 1895

(Figs 23A, B)

*Distoma deerrata* Sluiter, 1895: 167.

*Hypodistoma deerratum* - Kott 1990a: 106 and synonymy. - Monniot and Monniot 2001: 249.

**Records.** *New records:* Northern Territory (Darwin, Plater Rock, Mandorah Jetty, NTM E167, E209, E216). *Previously recorded* (see Kott 1990a, Monniot and Monniot 2001): NW Australia, NE Australia, Northern Territory, Torres Strait, Philippines, Papua New Guinea.

**Remarks.** This species is commonly recorded from northern Australian waters, but records from other parts of the western Pacific are not as common. It is found in inter-reefal benthic habitats.

### Family Polycitoridae

#### *Polycitor circes* Michaelsen, 1930

(Figs 5A,B, 23C,D)

*Polycitor circes* Michaelsen, 1930: 495. - Kott 1990a: 169 and synonymy. - Monniot and Monniot 1996: 184. - Monniot and Monniot 2001: 249.

**Records.** *New records:* Northern Territory (Darwin, Plater Rock, Mandorah Jetty, NTM E172, E179, E180, E215). *Previously recorded* (see Kott 1990a, Monniot

and Monniot 2001): NW Australia, N. Great Barrier Reef, New Caledonia, Philippines, Indonesia, Papua New Guinea.

**Description.** Colonies are up to 9 cm tall and consist of a spherical head to 4 cm diameter on a fleshy stalk of lesser diameter. Sometimes more than one stalked head arises from a basal common stalk. The test is firm, gelatinous, translucent in the head but more opaque in the stalk. Generally the test is whitish, but in several specimens brown spots of various sizes (Fig. 23C, D), formed by patches of fine pigment particles in the

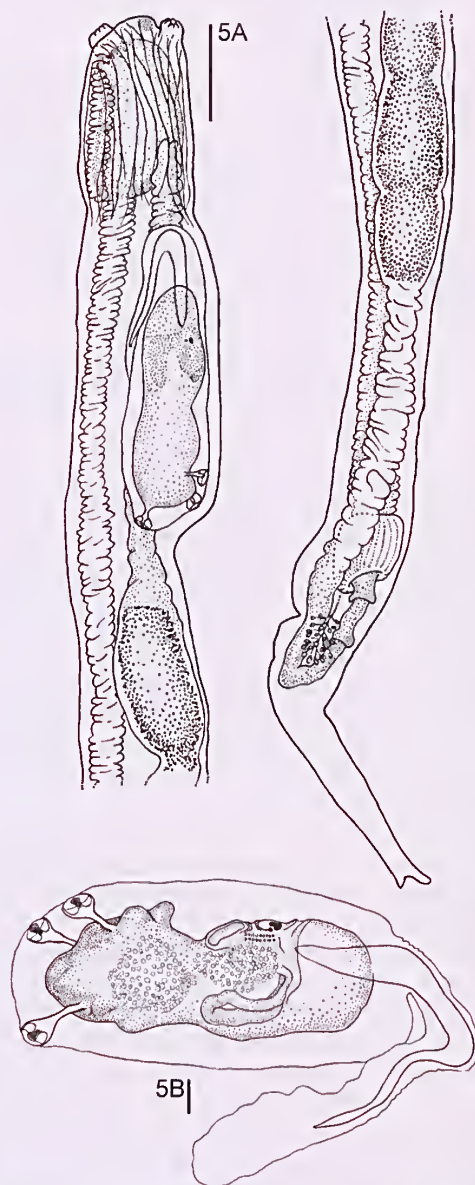


Fig. 5. *Polycitor circes*: A, (NTM E180) zooid; B, (NTM E179) larva. Scale bars: A, 1.0 mm; B, 0.2 mm.



surface test, are on the head. Zooids, even when strongly contracted, are 2 cm or more long, most of the length being a long oesophageal neck with oesophagus and rectum gathered into tight folds (Fig. 5A). Strong longitudinal muscles overlie the circular muscles on the thorax, and continue in a strong ventral band down the length of the abdomen. This ventral band of muscles swings dorsally at the posterior end of the abdomen. The small stomach, in the posterior end of the abdomen has 12–15 fine longitudinal ridges in the internal wall. Externally the stomach wall is smooth. The abdomen terminates in a short delicate, branched, vascular stolon.

A large larva is incubating at the top of the oesophageal neck in specimens taken July to September. One to three embryos are found developing at various levels up the oesophageal neck. The posterior end of the long (to 3 mm) narrow, larval trunk is uppermost. The short tail extends only halfway along the ventral surface of the trunk. The ocellus and small otolith are conspicuous not far from the base of the tail and two rows of stigmata can be detected in the larval pharynx. The anterior end of the trunk is produced into three rounded protuberances that alternate with the three triradially arranged adhesive organs, each with a small short-stalked, disc-like knob of adhesive cells in a shallow epidermal cup.

**Remarks.** It is clear from all accounts that the embryos, fertilised at the base of the abdomen, develop as they move up the long oesophageal neck.

Some of the present colonies have pigment patches that have not previously been recorded, although otherwise these stalked mushroom-like colonies are characteristic. The blue pigment Kott (1990a) reported in the zooids does not occur in the newly recorded, preserved specimens.

The circular systems Monniot and Monniot (1996) referred to were not detected. The correct reference to the synonymy of this species is in Kott (1990a), not Monniot and Monniot (1996).

***Eudistoma eboreum* Kott, 1990**

(Figs 23E,F)

*Eudistoma eboreum* Kott, 1990a: 205.

**Records.** *New records:* Northern Territory (Darwin, Plater Rock, Mandorah Jetty, NTM E187–8, E213). *Previously recorded* (see Kott 1990a): Queensland (near Lizard Island).

**Description.** Colonies are firm, irregular, gelatinous cushions with the margins sometimes produced into shallow lobes, grey or greyish-white in life. Spherical brown cells are scattered through the test of one (NTM E187) of the specimens and is in the surface test around the apertures in preserved material.

The stellate apertures are all ringed in white, up to 10 branchial ones in an outer circle and the atrial

openings close together in the centre of the circle. Atrial siphons are long. Zooids are contracted but have a long oesophageal neck. The proximal part of the rectum is kinked as a result of muscle contraction.

**Remarks.** Although these colonies have circular systems, they lack the rudimentary common cloaca found in many species of this genus. They also lack the pigmentation and the included sand of otherwise similar species.

***Eudistoma superlatum* Kott, 1990**

(Fig. 23G)

*Eudistoma superlatum* Kott, 1990a: 229.

**Records.** *New records:* Northern Territory (Darwin, East Point, NTM E156). *Previously recorded* (see Kott 1990a): NW Australia, Shark Bay, Houtman Abrolhos, Montebello Islands.

**Description.** This vertical flattened, tongue-shaped colony about 6 cm high has a translucent test, cloudy with pinkish-beige cells and a white suspension in the vicinity of the common cloacal apertures. Sand is embedded in the base and extends up into the centre of the lobe. Zooids, up to 1.5 cm long even when contracted, are arranged in circular systems with atrial apertures opening in the centre. The thoracic longitudinal thoracic muscles converge into a band each side of the long abdomen. Eleven transverse muscles are present beneath the more crowded longitudinal ones. Both conspicuous, long siphons have sphincter muscles behind the six-lobed apertures. Stigmata (about 20 per row) are long and rectangular and those in the anterior row extend anteriorly along each side of the mid-dorsal line. Ventrally, the stigmata are reduced in length each side of the endostyle. The small, almost spherical, stomach is at the posterior end of the zooid.

**Remarks.** Kott (1990a) did not detect the circular systems in the preserved colony. The deflection of the anterior row of stigmata along each side of the dorsal line is a distinctive feature of this species.

***Cystodytes philippinensis* Herdman, 1886**

(Fig. 23H)

*Cystodytes philippinensis* Herdman, 1886: 140.

- Kott in press and synonymy.

**Records.** *New records:* Northern Territory (Darwin, East Point, NTM E157). *Previously recorded* (see Kott in press): Queensland (Heron Island, Swain Reefs), Palau Islands, Philippines, French Polynesia, Maldives.

**Description:** As with all described material, the newly recorded specimen is grey with white blotches on the surface. In preservative, it has flecks of brown/tan pigment evenly scattered throughout the firm, translucent test. Globular spicules are in crowded patches around the cloacal depressions in the surface, but are not crowded throughout as sometimes they are.



## Family Polyclinidae

*Synoicum macroglossum* (Hartmeyer, 1919)

(Figs 24A,B)

*Macroclinum macroglossum* Hartmeyer, 1919: 126.*Synoicum macroglossum* - Kott 1992a: 494. - Kott in press.

**Records.** *New records:* Northern Territory (Darwin, Plater Rock, Iron Ore Jetty, NTM E168, E202). *Previously recorded* (see Kott 1992a): W and NE Australia.

**Description.** The colony is a sandy cushion with crowded thread-like zooids in crowded double row systems. Zooids have a large atrial tongue from the body wall in front of the atrial aperture, and a small smooth stomach. A dorsal papilla behind the atrial aperture was not detected in contracted zooids (NTM E168). In less contracted zooids (NTM E202) 12–14 rows of 14 stigmata per row, their length reducing at each end of the rows, were counted. The sand encrusting the outside of the colony is less crowded on the upper surface. Internally there is no sand and the zooids are crowded in the thin translucent test.

*Aplidium grisiatum* Kott, 1998

(Figs 6A,B, 24C)

*Aplidium griseum* Kott, 1992a: 551.*Aplidium grisiatum* Kott, 1998: 119. - Monniot and Monniot 2001: 208.

**Records.** *New records:* Northern Territory (Darwin, off East Point, NTM E151). *Previously recorded* (see Kott 1992a, Monniot and Monniot 2001): Queensland (S. Great Barrier Reef), Palau Islands.

**Description.** The newly recorded colony is an irregular, upright almost cylindrical column about 7 cm high, to 3 cm wide across the expanded top of the column and narrowing toward the base. The top of the colony is gelatinous and free of sand externally and internally. The upper surface is elevated into rounded ridges that surround depressions containing the branchial apertures of zooids arranged in circles, each circle around a central common cloacal opening. In the preserved specimens these opening are emphasised by brown pigment concentrated around them. Usually two or three systems open into each depression. In the remainder of the colony the long threadlike zooids criss-cross each other amongst the sand particles which are crowded throughout and encrust the surface. The anterior part of the thorax is produced up to form a cone at the base of the relatively short but muscular branchial siphon. The rim of each branchial aperture is divided into six distinct rounded lobes. A large muscular, undivided, pointed atrial tongue projects from the body wall just anterior to a circular atrial opening on a short siphon opposite the second row of stigmata. Stigmata are in 15 rows of about 15 per row,



Fig. 6. *Aplidium grisiatum* (NTM E151): A, colony; B, larva. Scale bars: A, 1.0 cm; B, 0.1 mm.

their length much reduced ventrally. The anus opens about halfway down the branchial sac. The short stomach, about halfway down the abdomen, has eight longitudinal folds. The gonads occupy only the posterior one-third or less of the long, narrow abdomen. They consist of two or three eggs anterior to two series of testis follicles. In many of the zooids one or two long embryos are lined up in the atrial cavity, the most advanced being anterior to the other. In the newly recorded specimens collected in September the larval trunk is 1.00 mm long, cigar-shaped, with the tail wound halfway around it. Three rows of stigmata and about 12 fine longitudinal muscles are on each side of the thorax.



**Remarks.** The zooids and larvae are identical with those previously assigned to this species although the upright colony is larger than Kott's (1992a) material and different from Monniot and Monniot's (2001) encrusting (1.0 cm thick) colony.

Monniot and Monniot (2001: 208) refer to meandriform systems, well isolated from each other, each with a central common cloacal aperture. However, although the depressions in the surface test certainly are meandriform in the present colony, the systems themselves are not. Also, sand outlines the depressions in the gelatinous surface in previously recorded colonies but not in the present one.

Sufficient material has been recorded to establish the characteristics of this species: viz. zooids open into the depressions between rounded ridges in the upper surface; sand is embedded in the basal test; zooids are thread-like with short protuberant branchial apertures, a pointed atrial tongue from the body wall anterior to a short atrial siphon, about 15 rows of about 14 stigmata, eight stomach folds, and gonads in the posterior third of the posterior abdomen; and the larval trunk is large, cigar-shaped with ectodermal vesicles in a wide band around the anterior two-thirds on each side of the midline.

*Aplidium multiplicatum* Sluiter, 1909

(Fig. 24D)

*Aplidium multiplicatum* Sluiter, 1909: 56. - Kott 1992a: 567 and synonymy. - Kott in press and synonymy.

**Records.** *New records:* Northern Territory (Darwin, Plater Rock, NTM E169, E181). *Previously recorded* (see Kott 1992a): NW and NE Australia, southern Australia, western Pacific and Hong Kong.

**Remarks.** The newly recorded colonies (Fig. 24D) are characteristically soft with zooids opening along each side of branched common cloacal canals. They have the usual white deposit around the branchial apertures of the preserved specimens (Kott 1992a).

**Family Didemnidae**

*Leptoclinides aciculus* Kott, 2001

(Figs 7A,B, 19A, 24E)

*Leptoclinides aciculus* Kott, 2001: 37.

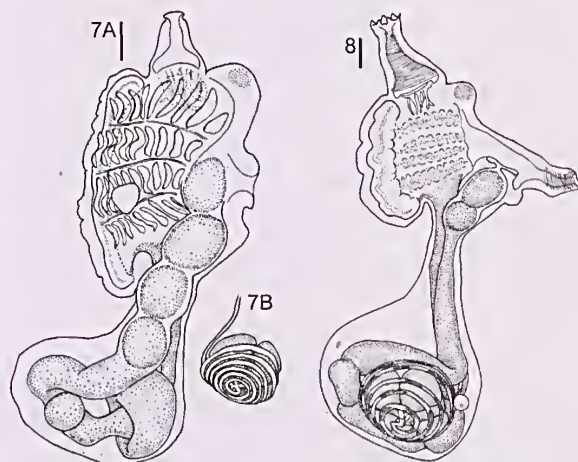
*Leptoclinides madara* - Monniot and Monniot 2001: 288.

**Records.** *New records:* Northern Territory (Darwin, Navy Base rock wall, Plater Rock, NTM E159, E166 E185). *Previously recorded* (see Kott 2001; Monniot and Monniot 2001): Western Australia (Port Hedland), Papua New Guinea, Palau Islands, Philippines.

**Description.** Colonies are flat sheets with clumps of zooids surrounded by deep primary common cloacal canals. Large sessile common cloacal apertures with a rim of spicule-free test are at some junctions of circular primary common cloacal canals. Sometimes the colony

surface over common cloacal canals is grey owing to the shallow depth of spicules in the relatively thin surface test. Superficially, spicules are mixed with bladder cells, crowded in minute surface papillae (see NTM E166) and around branchial apertures, evenly spaced but not crowded in the upper half of the colony and sparse or absent entirely from the base. Pigment cells are mixed with spicules in the roof and base of common cloacal canals. Spicules are stellate, to 0.096 mm diameter, with 11–13 long, chisel-shaped rays in optical transverse section. The ray length/spicule diameter ratio is to 0.33. In life, colonies are white with orange flecks (NTM E185) or cream with orange pigment over the common cloacal canals.

Zooids have a short branchial siphon, posteriorly directed atrial siphon, nine stigmata in the anterior row of the branchial sac (Fig. 7A); and seven coils of vas deferens around 4–7 testis follicles. Larvae, present in September (NTM E166), have a trunk up to 0.7 mm long, with three pairs of ectodermal ampullae.



**Fig. 7.** *Leptoclinides aciculus*: A, (NTM E159) whole zooid; B, (NTM E166) gonad. Scale bar: 0.1 mm.

**Fig. 8.** *Leptoclinides complexus* sp. nov. (NTM E13, holotype): zooid. Scale bar: 0.1 mm.

**Remarks.** The relatively sparse spicules, long chisel-shaped spicule-rays, together with the deep (but not posterior-abdominal) cloacal cavities and seven coils of the vas deferens distinguish this species. The newly recorded specimens have only nine stigmata in the first row of the branchial sac although 12 were recorded for the holotype. *Leptoclinides madara* Tokioka, 1953 from the Japan Sea and Sagami Bay (see also Nishikawa 1990), to which Monniot and Monniot (2001) assigned many specimens (of the present species) from the tropical western Pacific, has a similar larva but significantly smaller spicules (to 0.055 mm; Nishikawa 1990) and sometimes mulberry-like spicule rays. The spicule rays are never chisel-shaped as they are in the present species.



*Leptoclinides complexus* sp. nov.

(Figs 8, 19B)

**Records.** *Type locality:* Northern Territory (Table Head, Port Essington, coll. J. Hooper, 4 May 1982, holotype NTM E13; paratype NTM E12).

**Description.** In preservative, the holotype colony is a hard complex mass, dark purple externally and paler internally. External surfaces are enclosed by folding and fusing of the colony surface and most openings are secondary ones to enclosed outer surfaces. Common cloacal apertures are terminal on elevations of the surface, sometimes on parts of the colony elevated by the substrate. Dark pigment is in irregular masses in the base of colony, and is mixed with a thin layer of spicules beneath the spicule-free superficial layer of test. A thin (single) layer of spicules also lines the posterior abdominal common cloacal cavities. The paratype colony has a similar distribution of pigment as the holotype but is a single fleshy sheet encrusting an irregular substrate.

Spicules are stellate or mulberry-like (with short rounded rays). Stellate spicules are the larger ones – to 0.05 mm diameter, with 11–13 conical sharply pointed rays in optical transverse section.

Zooids are large, with a distinct branchial siphon, posteriorly oriented atrial siphon, four rows of stigmata, six coils of the vas deferens around 5–7 testis follicles and the post-pyloric part of the gut loop bent at right angles to the longitudinal axis of the zooid. Larvae, in the basal test of the holotype, have a trunk nearly 0.7 mm long but, apart from the tail, otolith and ocellus, the larval organs are not developed.

**Remarks.** The distribution of spicules, confined to a surface layer and a thin layer lining the common cloacal cavity, is not unusual in this genus (e.g. *dubius* group). However, mulberry-like spicules are an unusual feature in *Leptoclinides*, although similar ones occur in *L. comitus* (which lacks the stellate spicules).

The species' name refers to the complexity of the colony.

*Polysyncraton arafurensis* Tokioka, 1952

*Didemnum* (*Polysyncraton*) *arafurensis* Tokioka, 1952: 91.

*Polysyncraton arafurensis* - Kott 2001: 93 (part, not specimen QM G302266 from Heron Island, ? *P. regulum* Kott, 2001).

**Records.** *New records:* Northern Territory (Darwin, NTM E225). *Previously recorded* (see Kott 2001): Western Australia (Dongara), Arafura Sea.

**Description.** The newly recorded colony is a thin, hard, irregular sheet, crowded with stellate spicules and with a thin, horizontal, common cloacal cavity. The colony, spicules and zooids resemble those previously described. In particular, the atrial tongue from the upper rim of the opening is usually short, thin and often

bidentate at the tip (see Tokioka 1952: fig.1). Almost spherical embryos (to 0.6 mm long) are present in the newly recorded colony, but although the tail (wound three quarters of the way around the embryo) and a sensory vesicle with ocellus and otolith are present, other larval organs are not developed and are not known for this species.

*Polysyncraton cuculliferum* (Sluiter, 1909)

(Figs 9, 19C, 24F)

*Diplosomoides cuculliferum* Sluiter, 1909: 90.

Not *Didemnum cuculliferum* - Kott 1981: 164. – Kott 2001: 167. - Monniot and Monniot 2001: 267.

*Polysyncraton echinatum* Kott, 2001:101.

**Records.** *New records:* Northern Territory (Darwin, Plater Rock, NTM E174). *Previously recorded* (see Kott 2001): Queensland (Heron Island to Lizard Island), Indonesia (Sluiter 1909, holotype ZMA TU490).

**Description.** Fleshy colony growing over shell and bryozoan fragments with some vertical lobes projecting from the upper surface, each with a terminal common cloacal opening. Spicules are in a thin surface layer but are sparse or absent elsewhere. Spicules are stellate, to 0.057 mm diameter with 9–11 strong conical rays. The large, deep, common cloacal cavity extends the whole depth of the zooids. Both surface and basal test layers are thin. Around the outer margins of the colony, a hollow, pointed projection of the test accommodates a long, pointed ventral branchial lobe. Zooids are large with eight stigmata in the anterior row of the branchial sac. Longitudinal thoracic muscles are fine, and narrow transverse pharyngeal muscles between rows of stigmata are conspicuous. A retractor muscle was not detected but an anterior atrial lip usually is present. There is a roomy, open gut loop, 5–7 testis follicles are surrounded by four loose coils of the vas deferens, the outside loop encircling a two or three egg ovary.

The newly recorded specimen, collected in September, has well developed larvae in the basal test with eight ectodermal ampullae on each side of three antero-median adhesive organs and an external ampulla on the left projecting upwards rather than horizontally. The oozoid has a vertical gut loop and four rows of stigmata. Two thoracic blastozooids are in the trunk on the left side of the long oesophageal neck. The tail winds three-quarters of the way around the trunk.

**Remarks.** Sluiter (1909) described the male gonads of this species as having two testis follicles and a straight vas deferens. Kott (1981) accepted Sluiter's description of the testis and overlooked the fact that the holotype had more than two follicles, although she found the coiled vas deferens and assigned the species



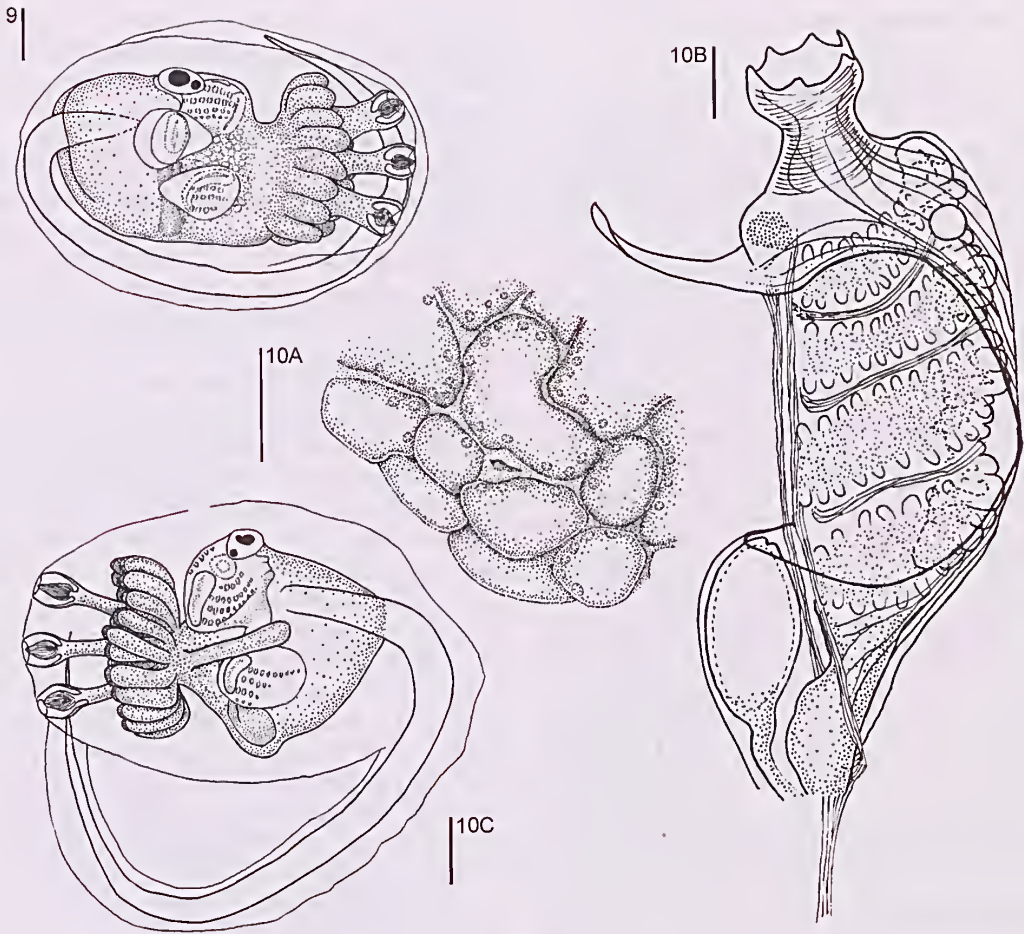


Fig. 9. *Polysyncraton cuculliferum* (NTM E174): larva. Scale bar: 0.1 mm.

Fig. 10. *Polysyncraton dromide* (NTM E211): A, colony; B, thorax; C, larva. Scale bars: A, 5.0 mm; B, 0.1 mm.

to the genus *Didemnum* (as the senior synonym of those species with a similar large ventral branchial lobe inserted into a hollow pointed surface papilla).

Further, spicules from the Fijian material (Kott 1981) are in the same size range as spicules of the holotype of *Polysyncraton cuculliferum*. However, although Kott (1981) claimed they were, they are not the same shape. Scanning electron micrographs of spicules of the type specimen of *P. cuculliferum* and of *P. echinatum* Kott, 2001 show them to be identical. The colonies also are similar, with vast common cloacal spaces and the spicules crowded in the surface and sparse elsewhere. The large zooids, with roomy branchial sac and gut loop, also are identical and in both cases are difficult to remove from the test. They have similar fine muscles, lack a retractor muscle and have an atrial lip of varying length.

Larvae in the newly recorded specimen are the most advanced known for this species. They are characteristic of many *Polysyncraton* species (and some

*Didemnum*), each of four primary ectodermal ampullae dividing into two, and with blastozooids. The oozooid is characteristic of the genus, with four rows of stigmata.

Kott (2001) also had assigned *Didemnum turritum* Michaelsen, 1930 from Western Australia to *Didemnum cuculliferum*, but although the colonies and zooids are small and lack gonads, examination of the small syntype colonies of *D. turritum* (ZMH T1701) shows the spicules to be identical with *D. membranaceum* Sluiter, 1909.

The other specimens Kott (1981, 2001) assigned to *D. cuculliferum* appear to be *Didemnum nekozita* Tokioka, 1967, having small colonies with smaller (0.04 mm diameter) spicules with 5–7 rod-like rays crowded throughout and occasional large (to 0.075 mm diameter) spicules with 4–6 long spiky rays, smaller thoraxes with no more than seven stigmata per row, a distinct retractor muscle, no atrial tongue, eight coils of the vas deferens and larvae with four pairs of lateral ampullae and without blastozooids.

*Polysyncraton dromide* Kott, 2001

(Figs 10A–C, 19D, 24G)

*Polysyncraton dromide* Kott, 2001: 99 (part, holotype).**Records.** *New records:* Northern Territory (Darwin, off East Point, Mandorah Jetty, NTM E154, E211). *Previously recorded* (see Kott 2001): Torres Strait, Western Australia (Cockburn Sound).**Description.** Translucent fleshy colony encrusting debris (NTM E154) or elevated lobes with terminal common cloacal apertures (NTM E211). Surface quilted (Figs 10A, 24G), with a mosaic of rounded sometimes spicule-free swellings surrounded by deep depressions over the circular common cloacal canals, which are lined on each side by zooids. The common cloacal apertures are in these deep depressions at the junctions of common cloacal canals. Burr-shaped spicules, to 0.05 mm diameter with 13–15 rays in optical transverse section, are in a single layer or in clumps beneath a superficial bladder cell layer where they are mixed with pigment. They sometimes are present only over the common cloacal canals, and occasionally they surround the thoraces. Spicules are absent from the remainder of the test. The common cloacal canals are the full depth of the zooids but are not posterior abdominal. The test is firm and gelatinous. In life, the colonies have a bright, metallic sheen.

Zooids have a trumpet-shaped branchial siphon with pointed lobes around the aperture, a sharply bifid but not long atrial lip, a robust to long and fine retractor muscle, 10–12 testis follicles and four coils of the vas deferens. The body wall has conspicuous projecting pointed columnar epidermal cells (see Kott 2001).

Larvae in specimens collected in September (NTM E154) and July (NTM E211) have a trunk 1.3 mm long with 10 ectodermal ampullae per side. Four rows of at least 10 stigmata are in the oozoid and in the large thoracic blastozooids. One of the blastozooids is halfway down on the right of the oozoid and another is on the left side of the oozoid abdomen. A conspicuous external horizontal ampulla also is on the left between blastozooid and oozoid. A narrow waist separates the base of the circle of lateral larval ampullae and the oozoid. The three deep, antero-median adhesive organs have narrow stalks and pyriform axial cones. The tail is wound halfway around the trunk. The large number of ectodermal ampullae result from subdivision of four broad primary ampullae, the middle ones on each side dividing into three. Large bladder cells are packed in the larval test.

**Remarks.** Characteristic of this species are its firm test, burr-shaped spicules in a thin layer beneath a superficial bladder cell layer but absent from the remainder of the test, regular circular common cloacal canals forming a quilted surface pattern, large larvae

(1.3–1.5 mm trunk) with two thoracic blastozooids and 10–12 ectodermal ampullae per side, and large zooids with a long retractor muscle and relatively short bifid atrial tongue.

On reexamination, the holotype has been found to have four coils of the vas deferens (rather than the three originally reported) and a large horizontal external ampulla on the left side of the trunk between the oozoid and blastozooid, as in the newly recorded specimens. The specimen from Western Australian (Kott 2001) with a different common cloacal system may not be conspecific.

The largest spicules in the newly recorded colony of the present species are larger than those Kott (2001) recorded and are nearly as large as those in *Polysyncraton purou* Monniot and Monniot, 1987. However, the latter species has smaller zooids, lacks an external horizontal ampulla on the left side of the larval trunk, lacks a narrow waist between the circle of lateral ampullae and the middle part of the larval trunk anterior to the oozoid, and, when present, the spicules have pointed rays rather than the blunt-tipped rod-like ones of the present species. The cloacal canals are like those of *P. purou*, and the bladder cells in the larval test of the present species also resemble those in *P. purou* and reported to be in the larval test (body wall, *sic*) of the darkly pigmented Philippine *P. aspiculatum* of Monniot and Monniot (2001), which may be a synonym of *P. purou* (see below).The suggestion that aspicular (or nearly aspicular) specimens from Australia, the Philippines and South Africa (Monniot and Monniot 2001) are conspecific with *P. aspiculatum* Tokioka, 1949 is discussed below (*P. purou*, Remarks).*Polysyncraton vestiens* Monniot and Monniot, 2001 from the Palau Island has spicules of similar form and distribution to the present species but they are smaller (to 0.03 mm diameter), larvae are slightly smaller (0.7 mm long trunk) and the retractor muscle is not present.*Polysyncraton pavementum* Monniot, 1993

(Figs 11A–B, 19E, 24H)

*Polysyncraton pavementum* Monniot, 1993: 9. - Kott 2001: 92 and synonymy.*Polysyncraton lithostrotum* - Monniot 1993: 4.Not *Didemnum lithostrotum* Brewin, 1956: 127.**Records.** *New records:* Northern Territory (Darwin, Plater Rock, NTM E170). *Previously recorded* (Monniot 1993): New Caledonia, Coral Sea.**Description.** Newly recorded colonies are thin, divided into circular to hexagonal systems 5–10 mm diameter, each with a central common cloacal aperture, violet coloured in life surround by opaque, solid, spicule-filled test. Colonies are white in preservative.



Spicules are confined to a surface and a basal layer. They are to 0.08 mm diameter, usually stellate, with 9–11 conical, usually pointed but sometimes round-tipped, rays in optical transverse section. Occasional spicules are almost globular. Primary common cloacal canals are deep with clumps of abdomina either embedded in, or projecting up from, the basal test. Spicules are not present in the ventral thoracic test sheath.

Zooids have cylindrical branchial siphons with six conspicuously pointed lobes around each aperture. Atrial apertures are wide, exposing most of the branchial sac to the common cloacal cavity. They have an atrial tongue of variable length projecting from the anterior rim of the opening. Tapering columnar epithelial cells project from the thoracic body wall. A short retractor muscle projects from the top of the oesophageal neck. Stigmata are obscured by contraction. Gonads are not present in the newly recorded material.

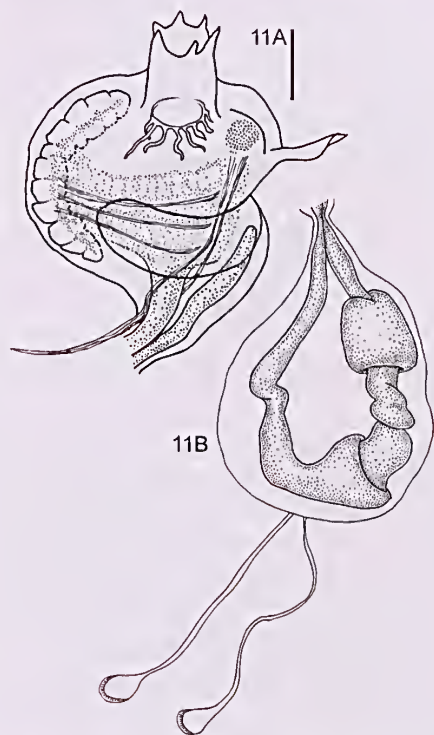


Fig. 11. *Polysyncrator pavementum* (NTM E170): A, zooid; B, abdomen. Scale bar: 0.2 mm.

**Remarks.** Despite the lack of information on the branchial sac, gonads and larvae, the newly recorded colony is exactly like previously described specimens. This record extends the known range of the species, which has not previously been recorded from Australia.

### *Polysyncrator pseudorugosum* Monniot, 1993

(Fig. 19F)

*Polysyncrator pseudorugosum* Monniot, 1993:10.  
- Kott 2001:123.

**Records.** *New records:* Northern Territory (Darwin, NTM E21). *Previously recorded* (see Kott 2001, Monniot 1993): Northern Territory, Torres Strait, Hervey Bay, New Caledonia.

**Description.** The newly recorded colony has some flattened branches which contain a hard central axis of particularly crowded spicules surrounded by a large common cloacal cavity interrupted by stands of solid test in which the ventral surfaces of thoraces are embedded. Abdomina are only partially embedded in the basal or axial test. Spicules are to 0.09 mm diameter with 9–11 conical pointed rays in optical transverse section. Zooids, with a small retractor muscle, resemble those of previously recorded specimens. Larvae in the newly recorded colony (collected in August) are incubated in the central or basal test and liberated through the common cloacal cavity. They have 12 ectodermal ampullae per side.

**Remarks.** The cloacal systems, zooids and larvae resemble those previously described. Spicules have a greater diameter than previously reported for this species, but on re-examination, some larger spicules (0.09 mm diameter as in present colony) have been found in a colony from Bathurst Island (QM G302910).

### *Polysyncrator purou* Monniot and Monniot, 1987

(Figs 12A–D)

*Polysyncrator purou* Monniot and Monniot, 1987: 49. - Kott 2001:126 and synonymy. \*

*Polysyncrator aspiculatum* - Monniot and Monniot 2001: 273.

**Records.** *New records:* Northern Territory (Darwin, NTM E224). *Previously recorded* (see Kott 2001, Monniot and Monniot 2001): Queensland (Heron Island, Mackay, Lizard Island); French Polynesia; Philippines.

**Description.** The colony is a flat, thin, gelatinous sheet with zooids along each side of the network of surface depressions over the thoracic primary cloacal canals. Common cloacal apertures are sessile and randomly distributed at the junctions of some of these canals. The surface layer of test contains crowded black and tan pigment cells and the colony is blackish-brown and opaque. The remainder of the test is whitish and translucent. The preservative is stained brownish-yellow. Spicules were not detected in this colony.

Zooids are not readily removed from the test. The branchial siphon is relatively short. The atrial aperture is sessile, relatively small, exposing only a small part

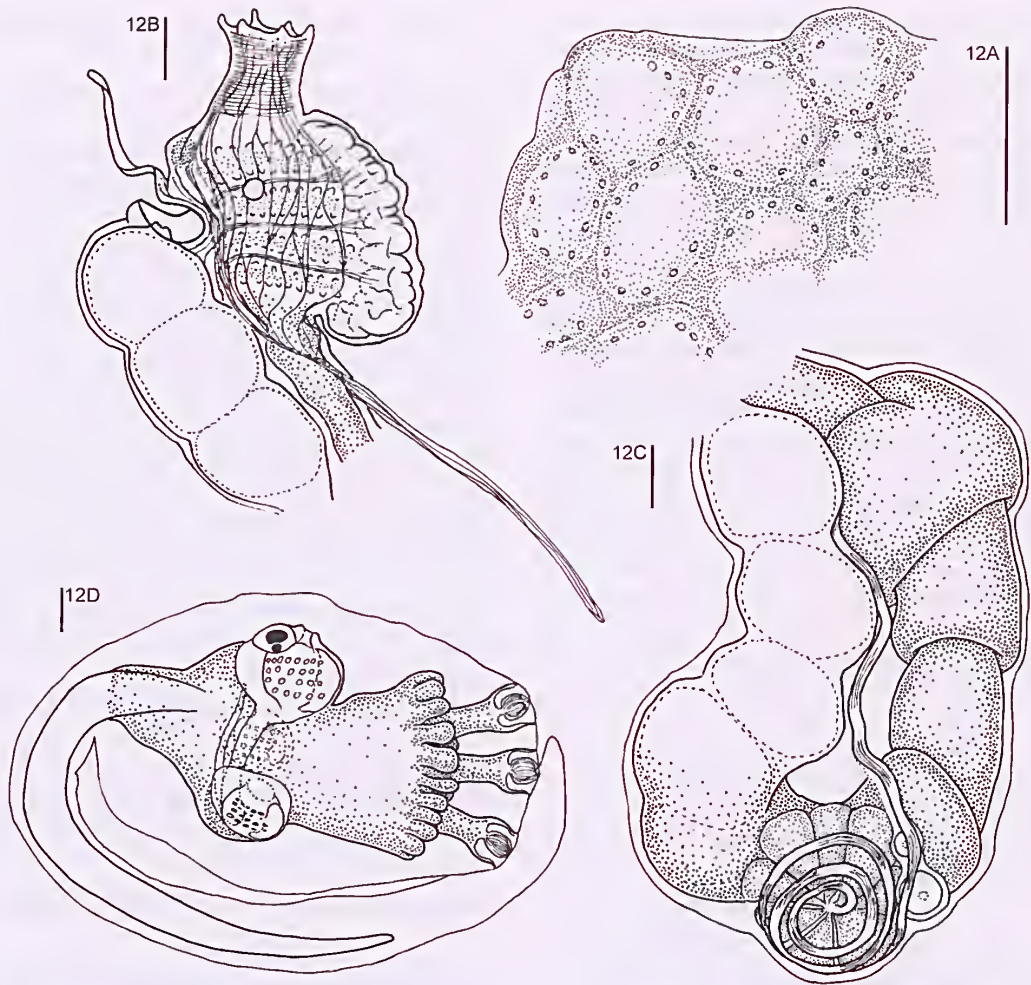


Fig. 12. *Polysyncraton purou* (NTM E224): A, colony surface; B, thorax; C, abdomen; D, larva. Scale bars: A, 5.0 mm; B-D, 0.1 mm.

of the mid-dorsal part of the branchial sac to the atrial cavity. A small atrial lip projects from the anterior rim of the opening. Fine longitudinal muscles are in the parietal wall of the thorax and a small circular lateral organ is antero-ventral to the atrial opening. The branchial sac is wide with about 10 stigmata in the anterior row. A short, robust retractor muscle projects from the anterior half of the oesophageal neck. In the newly recorded specimen a large monstrillid copepod and numerous nauplius larvae are in the gut of each zooid. A circle of four or five testis follicles are against the postero-dorsal part of the gut loop with four coils of the vas deferens, the outer coil enclosing a small ovary containing two small eggs and one larger one.

Embryos are being incubated in the basal test and larvae are liberated through the surface of the colony. The larval trunk is almost 1.4 mm long with the tail wound only halfway around it. Ten ectodermal ampullae are on each side of the three antero-median adhesive organs, the oozoid and two thoracic

blastozooids (one halfway down on the left and the other near the base of the gut loop of the oozoid on the right) each have four rows of stigmata. A small external horizontal ampulla on the left between the oozoid and the blastozooid is obscured by the blastozooid in these larvae. The middle part of the larval trunk, between the base of the lateral ampullae and the oozoid is particularly long in this species and the narrow waist that in other species separates the lateral ampullae from the oozoid was not detected. Large bladder cells are packed in the larval test.

**Remarks.** *Polysyncraton dromide* Kott, 2001, *P. palliolum* Kott, 2001 and *P. pseudorugosum* Monniot, 1993 have similar common cloacal systems and larvae to the present species. The last two species are readily distinguished by their crowded spicules, but the present species and *P. dromide* either have spicules in a patchy layer in the surface test, or completely lacking. When they are present, spicules can be used to distinguish these species, those of *P. dromide* being burr-like with



rod-like rays and those of *P. purou* having pointed rays. When the spicules are absent altogether, as they are in the newly recorded colony, the darkly pigmented surface test, darkly stained preservative and the long middle section of the larval trunk (with an ill-defined waist behind the lateral ampullae and the small inconspicuous external horizontal ampulla on the left) contribute to the identification of the species.

The restricted atrial aperture in zooids of the newly recorded colonies resembles that figured by Kott (2001), although she describes the atrial opening as wide, exposing much of the branchial sac. It is probable that this inconsistency results from different stages in the contraction of the zooids, rather than an actual difference in their morphology. Also, Kott (2001) incorrectly reported the tail of this species wound all the way around the trunk, although the figure shows it to be wound three-quarters of the way around – longer than in the newly recorded colony.

Monniot and Monniot (2001) assigned aspicular and almost aspicular specimens of *Polysyncrator* from Japan, Australia, the Philippines and South Africa to *P. aspiculatum* Tokioka, 1949 (not Tokioka, 1953 as in Kott 2001). However, despite similarities in the zooids, the Japanese species is distinguished from others by its globular spicules to 0.06 mm diameter with needle-like rays (see Nishikawa 1990) and its common cloacal systems – clearly defined systems with zooids along each side of the network of canals – never having been reported for specimens from Japan.

*Polysyncrator* ? *aspiculatum sensu* Monniot *et al.* (2001) from South Africa is distinguished from the present species by its white colony, fewer larval lateral ampullae (eight per side), and, when these are present, small (to 0.03 mm diameter) burr-like spicules with rod-like rays (similar to but smaller than those of *P. dromide*) rather than the stellate spicules of the present species. Kott (2001) has discussed the affinities of Australian specimens wrongly assigned to the Japanese species. The completely aspicular darkly pigmented specimen from the Philippines (Monniot and Monniot 2001) has affinities with the present species.

***Didemnum clavum* Kott, 2001**

(Figs 19G, 25A,B)

*Didemnum clavum* Kott, 2001: 164 and synonymy.

**Records.** *New records:* Northern Territory (Darwin, off East Point, Navy Base Rock Wall, Plater Rock, NTM E150, E158, E183). *Previously recorded* (see Kott 2001): NW Australia; Queensland (Heron Island, Swain Reefs); Northern Territory (Darwin), Indonesia.

**Description.** Newly recorded material includes a branching colony (NTM E150) with spicules crowded in a central axis to make a hard axial skeleton. Other specimens are thin sheets encrusting a hard substrate (Fig. 25A). The common cloacal cavity is thoracic.

Spicules to (0.06 mm diameter with 5–7 long pointed arms in optical transverse section) are crowded throughout.

Zooids have a particularly long oesophageal neck, the post-pyloric part of the gut loop bent ventrally at right angles to the longitudinal axis of the zooid, and eight coils of the vas deferens.

**Remarks.** The long oesophageal neck, thoracic common cloacal cavity, hard colony, simple stellate spicules with relatively few, long, pointed arms and numerous vas deferens coils are characteristic of the present species, known to be common in Darwin Harbour.

***Didemnum granulatum* Tokioka, 1954**

(Fig. 25C)

*Didemnum* (*Didemnum*) *moseleyi* f. *granulatum* Tokioka, 1954: 244.

*Didemnum granulatum* - Kott 2001 and synonymy: 188.

**Records.** *New records:* Northern Territory (Darwin, off East Point, NTM E152). *Previously recorded* (see Kott 2001): NW and NE Australia and Northern Territory, Tokara Island (Japan), Fiji, French Polynesia, Hawaii.

**Description.** The newly recorded colony (Fig. 25C) from Darwin has crowded stellate spicules, to 0.04 mm diameter, with 7–9 and occasionally 5–11 regular conical rays in optical transverse section. The common cloacal cavity is thoracic and zooids are small with seven stigmata in the anterior row and six coils of the vas deferens.

**Remarks.** The spicules resemble those of *Didemnum madeleineae* Monniot and Monniot, 2001, but are slightly larger and have a few more rays. They are of similar form to, and the same size as, *D. perplexum* Kott, 2001. Both these species are distinguished from the present one by having more vas deferens coils and larval ectodermal ampullae. The zooids and larvae of *D. algasedens* Monniot and Monniot, 2001 resemble the present species, although its colonies are small translucent cushions and usually its spicules have more rays (9–11) in optical transverse section).

***Didemnum madeleineae* Monniot and Monniot, 2001**

(Figs 13A,B, 19H, 25D–F)

*Didemnum madeleineae* Monniot and Monniot, 2001: 268.

**Records.** *New records:* Northern Territory (Darwin, Plater Rock, reef off Charles Point, NTM E178, E184, E203). *Previously recorded* (Monniot and Monniot 2001): Papua New Guinea.

**Description.** Newly recorded colonies are encrusting sheets about 2 mm thick, pink to orange-red in life and sometimes with a ring of dark reddish pigment around the white-rimmed, randomly

distributed common cloacal apertures. Some traces of orange pigment are in the surface of preserved specimens. Branchial apertures are evenly spaced. Spicules are crowded throughout and are also in the minute papillae on the surface. They are stellate, to 0.045 mm diameter with 5–7 conical rays in optical transverse section. The common cloacal cavity is thoracic.

Zooids are about 1.3 mm long with a long retractor muscle from about halfway down the oesophageal neck. Branchial apertures are short, and cylindrical with six sharply pointed lobes. Stigmata are relatively long, and seven are in the anterior row. The post-pyloric part of the gut loop is bent up ventrally and the testis, with eight coils of the vas deferens, is against its dorsal side. Larvae are not present in the newly recorded specimen but those in the type material have a large trunk (about 1 mm long) containing 12 pairs of ectodermal ampullae around the three antero-median adhesive organs. Although none were detected in the relatively rudimentary larva from the type material, these large trunks with many ectodermal ampullae could contain blastozooids.

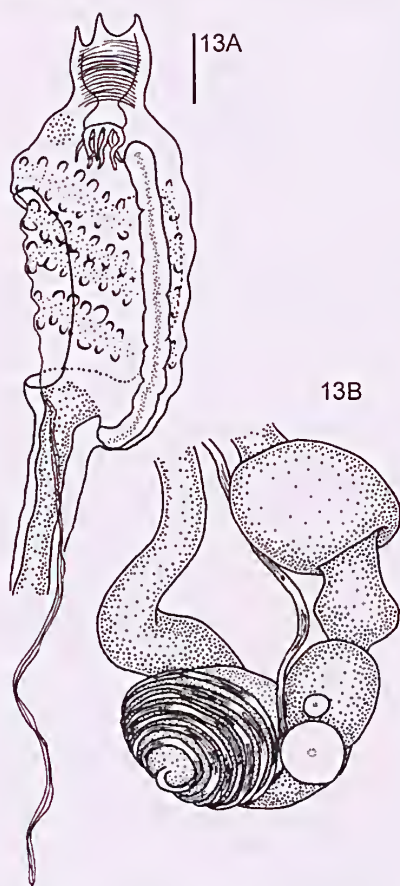


Fig. 13. *Didemnum madeleineae* (NTM E184): A, thorax; B, abdomen. Scale bar: 0.1 mm.

**Remarks.** Several living colonies (Fig. 25D, E) resemble a juvenile specimen of *Didemnum multispirale* Kott, 2001 (see Kott 2001: pl. 12A). However, their spicules are identical in size and form with those from the type material of *D. madeleineae* (see Monniot and Monniot 2001: fig. 54A), being relatively small and distinctly stellate with relatively few conical rays. Another colony (NTM E203) is pink. Otherwise the newly recorded colonies are similar to the orange coloured type, although they have lost their colour in preservative. The figured zooid (Monniot and Monniot 2001: fig. 53) has eight coils of the vas deferens like the present specimens, but only seven coils are reported in the type.

The spicules are similar to, but smaller than, those of *Didemnum perplexum* Kott, 2001 and *D. granulatum*, the larvae have more numerous ectodermal ampullae, and there are more coils of the vas deferens (seven in *D. perplexum* and six in *D. granulatum*). *Didemnum captivum* Monniot and Monniot, 1997, from Tanzania, is similar to the present species, distinguished only by its smaller larval trunk and fewer ectodermal ampullae.

#### *Didemnum membranaceum* Sluiter, 1909

(Fig. 20A)

*Diplosomoides membranaceum* Sluiter, 1909: 58. - Kott 2001: 205 and synonymy.

*Didemnum turritum* Michaelsen, 1930: 521.

**Records:** *New records:* Northern Territory (Darwin, Plater Rock, NTM E165). *Previously recorded* (see Kott 2001): NE and NW Australia, Timor Sea, Andaman Sea, Indonesia, Micronesia, French Polynesia, Hong Kong.

**Description.** Although gonads were not detected in the newly recorded colony, it is the characteristic thin encrusting sheet with small zooids, shallow thoracic common cloacal cavity and crowded stellate spicules with pointed conical rays (including occasional giant spicules). In life it is red with raised white areas where the spicules crowd out the pigment.

The syntypes (ZMH T1701) of *Didemnum turritum* Michaelsen, 1930 from Shark Bay (WA), have been reexamined. These small, thin colonies, like some of the present species, usually have rows of pointed surface processes, one associated with each branchial aperture as is characteristic of *Polysyncrator cuculliferum*, *Didemnum nekozita* and other species (see Kott 2001). Spicules (which are crowded throughout) are also like those of the present species, the majority being stellate, with 7–11 long, sharply pointed, conical rays up to 0.05 mm diameter, and some randomly distributed large (to 0.08 mm diameter) six-rayed spicules. The small zooids with comma-shaped thoraces and up to six stigmata in the anterior row (see Kott 2001: fig. 98B, C) also are similar to the present species. Gonads were not detected. This species appears to be a junior synonym of *D. membranaceum*.



*Didemnum algasedens* Monniot and Monniot, 2001 has small (to 2.5 cm diameter and only 1 mm thick) colonies and spicules like the smaller ones in the present species. However, the larger tetrahedral to 6-rayed spicules characteristic of the present species have not been reported and there are said to be eight (rather than six) coils of the vas deferens.

***Didemnum molle* (Herdman, 1886)**

*Diplosomoides molle* Herdman, 1886: 310.

*Didemnum molle* - Kott 2001: 208 and synonymy. - Monniot *et al.* 2001: 51.

**Records.** *New records:* Northern Territory (Darwin, Mandorah Jetty, NTM E217). *Previously recorded* (see Kott 2001, Monniot *et al.* 2001): Indo-west Pacific, from W Indian Ocean to Okinawa, Vietnam and Fiji. Although Monniot *et al.* (2001) claim that the record of the species from coralline habitats on the African coast north of Durban (29° 85'S) is the most southerly for this species, it was recorded from the Western Australian coast in Cockburn Sound (32° 10'S) and Esperance (33° 45'S) by Kott (1977, 2001).

**Remarks.** The abundant mucus referred to by Monniot *et al.* (2001) is secreted and liberated from the colony following disturbances. It is not normally contained in the colony (see Kott 1980). The extensive synonymy for this species is documented by Kott (1977, 1980 and 2001) rather than Monniot (1994).

***Didemnum parau* Monniot and Monniot, 1987**

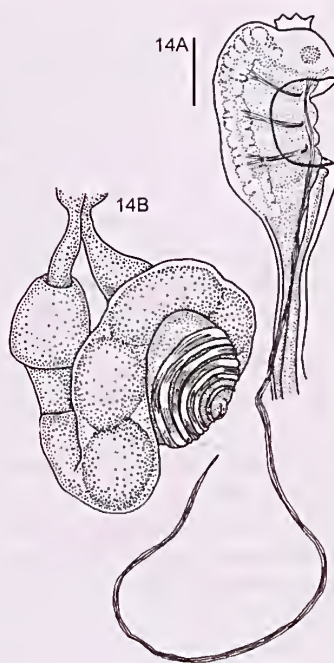
(Figs 14A,B, 20B, 25G)

*Didemnum parau* Monniot and Monniot, 1987: 39.

**Records.** *New records:* Northern Territory (Darwin, off East Point, NTM E153). *Previously recorded* (see Kott 2001, Monniot and Monniot 1987): French Polynesia, Philippines.

**Description.** White when living, the newly recorded preserved colony has brown pigment mixed with spicules in the surface. Burr-like to globular spicules, to 0.03 mm diameter, are crowded through the remainder of the test, although they are absent from the fleshy rim of common cloacal apertures. Thoraces are separate from one another and abdomina are partially embedded in the basal test or clumped together in test connectives and surrounded by common cloacal cavity. Spherical black cells are in the test and free of it around the zooids. Zooids have a long thin retractor muscle and seven coils of the vas deferens around an undivided testis.

**Remarks.** Spicules of the present species resemble those of *Didemnum fragile* and *D. albopunctatum*. The newly recorded colony conforms with previous descriptions of this species, although the spherical brown cells surrounding the zooids (as in *D. fuscum* and *D. sordidum*) have not previously been reported. Refrangent morula cells are recorded (Monniot and Monniot 1987).



**Fig. 14.** *Didemnum parau* (NTM E153): A, thorax; B, abdomen. Scale bar: 0.1 mm.

***Didemnum perplexum* Kott, 2001**

(Figs 20C, 25H)

*Didemnum perplexum* Kott, 2001: 224 and synonymy.

**Records.** *New records:* Northern Territory (Darwin, reef off Charles Point, NTM E206). *Previously recorded* (see Kott 2001): Queensland (Capricorn Group, Swain Reefs), New Caledonia, Indonesia.

**Description.** The newly recorded colony is a soft white encrusting sheet, even on the upper surface but with variations in the thickness of the colony compensating for an irregular substrate. Spicules are crowded throughout but not so crowded that the colony is brittle. In the surface are what appear to be spherical vesicles with ridges of spicule-filled test or small spicule-filled papillae between these vesicles creating an areolar pattern that is interrupted by stellate branchial apertures with their margins lined by spicules. The preserved colony is white with a pinkish tinge.

Spicules are stellate to 0.05 mm diameter with 5–9 long pointed rays in optical transverse section, some distinctly conical but others almost rod-like. A spherical plug of spicules from a large spherical lateral organ opposite the interspace between the third and fourth rows of stigmata is on the edge of the spicule-filled ventral test sheath associated with each thorax as it crosses the deep horizontal common cloacal cavity. The abdomina are embedded in the basal test and only sometimes project up into the floor of the common cloacal cavity.

Zooids lack an atrial lip, have a fine retractor muscle, eight stigmata in the anterior row of the branchial sac, the post-pyloric part of the gut loop flexed ventrally to form a secondary loop and seven coils of the vas deferens surround an undivided testis.

**Remarks.** Brighter colours have been reported for the type material. However, the newly recorded colony has similar zooids, colonies and spicules and appears to belong to this species. The spicules are similar to, but have longer and some more rod-like rays than the short conical rays of *Didemnum madeleineae*.

*Didemnum psammatoide* (Sluiter, 1895)

(Figs 20D, 26A)

*Leptoclinum psamathodes* Sluiter, 1895: 171.

*Didemnum psammatoide* - Kott 2001: 229 and synonymy.

**Records.** *New records:* Northern Territory (Peron Island, QM G303646; Shoal Bay, QM G303655; Darwin, Shore Reef, East Point, Channel Rock, Iron Ore Wharf, reef off Charles Point, NTM E10, E27, E30, E201, E205, E207). *Previously recorded* (see Kott 2001): The species has a wide recorded range in the Indian and Pacific Oceans. It has not been reported from either the Atlantic Ocean or the Mediterranean Sea.

**Description.** The newly recorded colonies are all large. Some are narrow branching stalks that are thicker toward the base. The maximum stalk diameter is about 1 cm. Sometimes the stalks coalesce and form a reticulum. The centre of each stalk is packed with faecal pellets. Other colonies are encrusting, sometimes with some cylindrical outgrowths from the surface. Spicules sometimes (NTM E30, E205, QM G303655) are crowded in the surface test, forming a continuous layer of white that obscures the grey of the faecal pellets and also may shade the colony. In one of these colonies (QM G303655) spicules also are packed in the ventral test sheath (associated with the thorax crossing the common cloaca) and in the floor of the common cloaca. In several colonies (NTM E201, E207) the spicules are in small patches around the common cloacal and branchial apertures and in a thin veil on the base of the colony. The spicules are mainly burr-shaped, never more than 0.035 mm in diameter but only occasional globular or stellate spicules (as in Kott 2001: fig. 168A) were detected.

**Remarks.** Complex branched colonies have been reported previously for this species. Spicules crowding the surface test have not previously been reported and generally they appear to be more crowded in large branching colonies, than in sheet-like ones. Nevertheless, spicules are never crowded in either the basal test or the central test of cylindrical branches. In this species the central axis supporting the branches of complex colonies is formed of crowded faecal pellets

rather than the packed spicules found in certain species (e.g. *Didemnum clavum* Kott, 2001, *Trididemnum sibogae* Hartmeyer, 1910).

Spicules are all less than 0.037 mm diameter. There is some variation in the extent to which the rays may separate out.

*Trididemnum marmoratum* (Sluiter, 1909)

(Figs 15A,B, 20E, 26B)

*Leptoclinum marmoratum* Sluiter, 1909: 84.

**Records.** *New records:* Northern Territory (Gulf of Carpentaria, QM G308587, AIMS 17953). *Previously recorded:* Indonesia (Sluiter 1909).

**Description.** The colony is fleshy, flattened, with randomly distributed sessile common cloacal apertures and occasional elevated lobes and ridges. The test is firm but gelatinous and translucent. Zooids are in clumps surrounded by deep primary common cloacal cavities that spread into extensive horizontal posterior abdominal spaces interrupted by connectives anchoring zooid clumps to the basal test. Oesophageal spaces penetrate amongst the zooids in each clump. Spicules

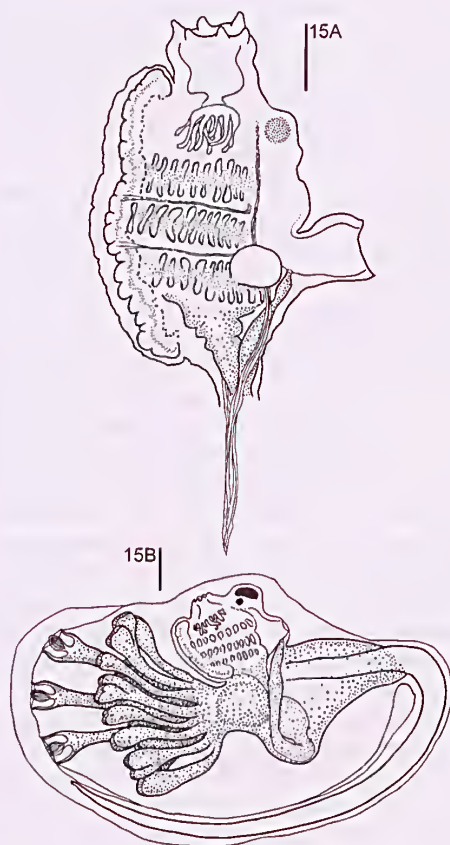


Fig. 15. *Trididemnum marmoratum* (QM G308587): A, thorax; B, larva. Scale bars: 0.1 mm.



are in a crowded layer beneath a superficial spicule-free bladder cell layer and in an even but less crowded layer lining the common cloacal cavity. They are completely absent from the basal test. Spicules are large, stellate, to 0.08 mm diameter, with 9–11 short, strong, conical or chisel-shaped rays in optical transverse section, sometimes with a bifid tip. They break up readily.

Zooids are robust with a short, cylindrical branchial siphon and short posteriorly oriented atrial siphon from the posterior third of the dorsal border. Extensive anterior and posterior imperforate areas are in the pharynx. About 10 stigmata are in each row in the branchial sac. A large, robust retractor muscle projects from the posterior end of the thorax. The gut forms a slightly curved loop, but gonads are not present in this specimen. Large larvae, (taken in February), with the trunk 1 mm long and the tail curved only halfway around it, are numerous in the basal test. Eight long ectodermal ampullae are developed on each side of three antero-median adhesive organs. Ampullae have expanded and curved tips with long epidermal cells along their terminal ends. Both larval and adult organs are well-formed in these larvae.

**Remarks.** The species has similar firm gelatinous test and larval ectodermal ampullae to *Trididemnum discrepans* (Sluiter, 1909). However, it lacks the black pigment, the black squamous epithelium and the endostylar pigment cap of the latter species and has smaller zooids and fewer stigmata. It is distinguished from other species of *Trididemnum* by its relatively small larval trunk with more ectodermal ampullae. The spicules also are unusual, the wide chisel-shaped to subdivided tips resembling most closely those of the temperate species, *T. cristatum* Kott, 2001 which is distinguished by the absence of posterior abdominal cloacal cavities and its smaller larvae with only four pairs of ectodermal ampullae.

***Trididemnum planum* Sluiter, 1909**

(Figs 16A–C, 20F, 26C)

*Trididemnum planum* Sluiter, 1909: 42. - Kott 2001: 256.

**Records.** *New records:* Northern Territory (Darwin, Plater Rock, NTM E191, E192). *Previously recorded* (see Kott 2001): Indonesia.

The species characters are summarised by Kott (2001).

***Trididemnum savignii* (Herdman, 1886)**

(Fig. 26D)

*Didemnum savignii* Herdman, 1886: 261.

*Trididemnum savignii* - Kott 2001: 281 and synonymy.

**Records.** *New records:* Northern Territory (Darwin, Mandorah Jetty, NTM E214). *Previously recorded* (see Kott 2001): NW Australia, NE Australia, Darwin, Indonesia; West Indies.

**Description.** Colonies are characteristic firm, grey, gelatinous slabs with black pigment cells throughout and a layer of large stellate spicules beneath a superficial layer of bladder cells. Zooids have black squamous epithelium, a long tapering retractor muscle, an endostylar pigment cap, a posteriorly oriented atrial siphon, and eight coils of the vas deferens around an undivided testis.

***Trididemnum sibogae* (Hartmeyer, 1910)**

(Fig. 17)

*Didemnum sibogae* Hartmeyer, 1910: 1489 (nom. nov. for *Didemnum ramosum* Sluiter, 1901).

*Trididemnum sibogae* - Kott 2001: 285 and synonymy.

**Records.** *New records:* Western Australia (? Port Hedland, NTM E35); Northern Territory (Darwin, East Point, NTM E19). *Previously recorded* (see Kott 2001): NW Australia; South Australia; Tasmania; New South Wales; NE Queensland; Gulf of Carpentaria; Indonesia; New Caledonia; Gulf of Manaar.

**Description.** Newly recorded colonies are spiky, complex, branching lamellae that form three-dimensional reticula (see Kott 2001: fig. 132A). In preservative, one colony (NTM E19) is grey-black, and the other is an opaque pinkish-white. Zooids have black squamous epithelium and an endostylar pigment cap. Extensive common cloacal cavities are posterior abdominal either surrounding a central test core (NTM E35) or occupying the whole centre of the branch or lobe (NTM E19). Spicules with 9–11 spiky rays in optical transverse section are large (to 0.09 mm diameter) in the Darwin specimen (NTM E19) but smaller (to 0.065 mm) in the Port Hedland material. They are crowded throughout, especially where they are packed to form a hard supporting axial skeleton in the central test or along one side of the central common cloacal cavity in the specimen from Darwin. The axial skeleton is continuous, branching with the branching of the colony. Larvae are present only in the Port Hedland specimen (taken in September). They differ from previously recorded material (see Kott 2001) from the Gulf of Carpentaria (QM G303519) and Port Hacking (AM Z5136, QM GH32) in their size – the trunk length, being 0.55 mm (rather than 0.7 mm), and the relative length of the tail (which winds almost the whole way around the trunk rather than halfway).

**Remarks.** The specimen from Port Hedland has significantly smaller spicules and smaller larvae with a relatively longer tail than the previously reported specimens of this species. Further, it is an unusual opaque pink colour in preservative. Its assignation to this species is in doubt.

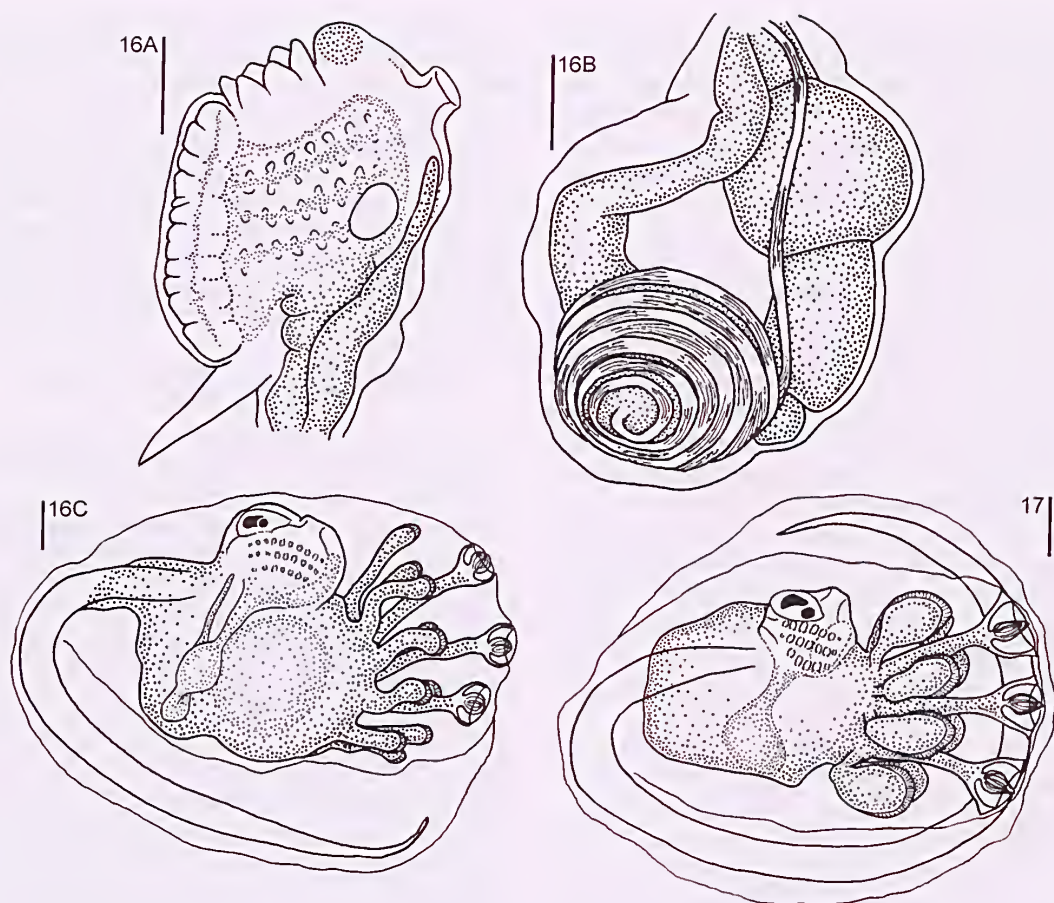


Fig. 16. *Trididemnum planum* (NTM E191): A, thorax; B, abdomen; C, larva. Scale bar: 0.1 mm.

Fig. 17. *Trididemnum sibogae* (NTM E35): larva. Scale bar: 0.1 mm.

***Lissoclinum badium* Monniot and Monniot, 1996**  
(Figs 26E–H)

*Lissoclinum badium* Monniot and Monniot, 1996: 170 - Monniot and Monniot 2001: 282. - Kott 2001: 296.

**Records.** *New records:* Northern Territory (Darwin, Plater Rock, NTM E173, E186, E190). *Previously recorded* (see Kott 2001, Monniot and Monniot 2001): NW Australia, NE Australia (Capricorn Group to Lizard Island), Coral Sea, Palau Islands, Papua New Guinea.

**Description.** One newly recorded specimen (NTM E186) conforms with previously described and photographed specimens (see Monniot and Monniot 1996; Kott 2001). The other two have more crowded spicules throughout, including crowded spicules surrounding the zooids in the test connectives and throughout the surface layer of test. Some yellow but not much brown pigment is in the surface test, mixed with the spicules. The living specimens are various

shades of cream, yellow to brown, but in preservative the dark vesicles scattered in the test around the zooids and in the haemocoel are conspicuous against the crowded white spicules.

**Remarks.** The form of the colony, with large common cloacal apertures which, in living specimens, are terminal on elevations resulting from inflation of the common cloacal cavity, are characteristic of this species.

***Lissoclinum conchylum* Kott, 2001**  
(Figs 18A, 20G, 27A)

*Lissoclinum conchylum* Kott, 2001: 350.

**Records.** *New records:* Northern Territory (Darwin, Plater Rock, NTM E221). *Previously recorded* (see Kott 2001): Queensland (Moreton Bay, Heron Island).

**Description.** The thin, encrusting colony has the crowded spicules mixed with dark plum-coloured pigment cells in the surface test interrupted by double circles of vesicles that surround each branchial aperture.



Pigment also is mixed with spicules in the floor of the deep thoracic common cloacal cavity and in the layer of test surrounding the abdomina embedded in the basal test (comprising the lower half of the colony). Spicules are crowded in the basal layer of test, which is white, opaque and brittle. Spicules are globular (with flat-tipped rays) and burr-like, to 0.055 mm diameter.



Fig. 18 A, *Lissoclinum conchylum* (NTM E221): larva. Scale bar: 0.1 mm; B, *Lissoclinum multifidum* (NTM E212): zooid. Scale bar: 0.2 mm.

Zooids have relatively large thoraces that cross the common cloacal cavity, each with a strap-like ventral test sheath also filled with spicules. The branchial sac is directly exposed to the common cloacal cavity. Zooids have dark brown cells in the haemocoel, especially conspicuous in the interstigmatal bars and transverse branchial vessels. The branchial sac has nine stigmata in an anterior row. Distinct longitudinal parietal muscles are present but neither retractor muscle nor atrial tongue were detected. The testis is divided into two with a straight vas deferens curving around between the follicles.

Larvae, present in the newly recorded specimen (collected in July), have a large and almost spherical (deeper than long) trunk 0.6 mm long, with the tail wound two-thirds of the way around it. The cerebral vesicle is protuberant, the pharynx has four rows of stigmata, and four ectodermal ampullae with modified cells along their tip are along each side of the three antero-median adhesive organs.

**Remarks.** The mauve colour, brittle test, brown cells in the haemocoel, large branchial sac, two testis follicles and absence of a retractor muscle are all characteristic of this species which, though not previously recorded from north of Heron Island, is now confirmed as a tropical species and can be expected to occur more widely in northern Australia.

#### *Lissoclinum durable* Kott, 2001

(Fig. 27B)

*Lissoclinum durable* Kott, 2001: 306.

**Records.** *New records:* Northern Territory (Darwin, reef off Charles Point, NTM E204). *Previously recorded* (see Kott, 2001): southern Australia (Esperance to Western Port); New South Wales.

This is the first record of this species from the tropics. It previously was thought to be a temperate species.

**Description.** In life and in preservative, the colonies of the species have a characteristic purple/yellow marble pattern – purple over the common cloacal canals and around the common cloacal apertures and yellow over the zooids (see Kott 2001: pl. 19B). The pigment is in minute spherical cells in the superficial test. Spicules are crowded throughout the test. Spicules are burr-like, to 0.04 mm diameter, with 15–17 rod-like to round-tipped club-shaped rays in optical transverse section. The ventral margins of up to four thoraces are stretched out along the hard, rigid and brittle pillars or straps of test that span the thoracic common cloacal cavity. The rectangular stigmata are exposed directly to the common cloacal cavity, only a narrow strip of pallial wall lying along each side of the endostyle. An atrial cavity is not present. Zooids lack both conspicuous longitudinal muscles and a retractor muscle. On the

surface of the colony, each branchial aperture is surrounded by spicule-free test and is depressed into a small concavity surrounded by the hard circular rim of spicule-filled surface test. Zooids have brown cells in the haemocoel, and the testis is divided into two follicles.

**Remarks.** Colony form, colour and the zooids (including the spherical brown cells in the haemocoel) are identical with previously recorded material from temperate waters.

*Lissoclinum limosum* Kott, 2001

(Figs 20H, 27C)

*Lissoclinum limosum* Kott, 2001: 310.

**Records.** *New records:* Northern Territory (Darwin, Plater Rock, NTM E175, E182). *Previously recorded* (see Kott 2001): southern Great Barrier Reef.

**Description.** Colonies are delicate irregular sheets, translucent but with veins of brown pigment forming a network in the surface test around groups of four to eight zooids. The minute spicules form a capsule around the zooids. Common cloacal cavities are extensive, horizontal cavities. The testis is undivided.

**Remarks.** The newly recorded colonies generally conform with those previously described, although the common cloacal cavity is more extensive.

*Lissoclinum multifidum* Sluiter, 1909

(Figs 18B, 27D,E)

*Lissoclinum multifidum* Sluiter, 1909: 83 - Kott 2001: 311.

**Records.** *New records:* Northern Territory (Darwin, Mandorah Jetty, NTM E210, E212). *Previously recorded* (see Kott 2001): Northern Territory (Port Essington), Indonesia, Gulf of Thailand, Mauritius.

**Description.** The newly recorded colonies are fleshy and gelatinous. One (NTM E210) is a broad, irregular slab with randomly spaced common cloacal apertures. The other (NTM E212) is a narrow, cylindrical V-shape (Fig. 27E), about 1.5 cm wide with the zooids arranged along each side of almost parallel common cloacal canals across its width and large common cloacal apertures with areas of clear test around them where the canals converge (usually near the edge of the colony). Some cloacal canals are deep, extending beneath the zooids and forming large posterior abdominal spaces crossed by relatively few test connectives tying the upper part of the colony to the basal test. The primary common cloacal canals separate clumps of zooids from each other. Secondary canals penetrate amongst the zooids in each clump at thorax level (Fig. 18B). The long retractor muscles extend down into the basal test through the test connectives. Conspicuous opaque granular but non-calcareous vesicles (to 0.05 mm diameter) are in the test, especially in the surface between the rows of

zooids but also they are present around the zooids. They are absent from the basal test where embryos are being incubated in the narrow colony (NTM E212).

The *in situ* photographs of the two newly recorded specimens (both taken from a reef, Mandorah Jetty, 7–9 m, 16 July 2001) show their appearance in life to be dramatically different (see Fig. 26D,E). One colony (NTM E210) is orange and similar to *Lissoclinum concavum* Kott, 2001 (pl.18H); and the narrow cylindrical V-shaped colony (NTM E212), has white bands across it, alternating with the transparent test. Small, sparsely distributed, burr-like spicules (to 0.015 mm) are in the orange specimen but not in the white one and in both the white colour is conferred by the characteristic spherical cells in the surface test and around the zooids.

Zooids are about 1.5 mm long, with 12 stigmata in the anterior row and a circle of up to 10 testis follicles. The ovum projects from the zooid, separated from it by a short, narrow constriction. Larvae, present in the larger colony (collected in July) have a trunk 1.0 mm long – longer than previously recorded – with the tail wound halfway around it. The usual three lateral ectodermal ampullae are on each side, an abdominal blastozooid is on the right side of the oozooid, a thoracic bud is on the left, three deep antero-medial adhesive organs have long, narrow stalks and pyriform axial cones, and the cerebral vesicle protrudes anteriorly. One larva with only two antero-medial adhesive organs was observed but this appears to be abnormal.

**Remarks.** Despite their dramatically different appearance in life, preserved specimens cannot be distinguished from each other nor from other (previously recorded) specimens. The presence of a few small burr-like spicules in the specimen that most closely resembles *Lissoclinum concavum*, suggests a close relationship with that species and the difference in the size and distribution of spicules present may be the only distinguishing character available. At this stage, the larva of *L. concavum* is not known.

*Lissoclinum multitestis* (Monniot and Monniot, 1996) originally assigned to *Diplosoma* because it has an aspicular colony, has 5–7 testis follicles and a straight vas deferens like the present species. The larva also appears to be characteristic of *Lissoclinum*, with the oozooid in the centre of the trunk, and it has three antero-medial adhesive organs and six pairs of ectodermal ampullae. The species, like *L. concavum*, appears to be closely related to the present one, and the dramatic differences implied in the original description of *L. multitestis* may be the result of misinterpretations. The implications that gonads are in a pouch of the body wall, and that a position in the gut loop is their more usual location (see Monniot and Monniot 1996: 169) are both incorrect. They are in the



usual position against the nominally dorsal side of the gut loop, *i.e.* behind the ventrally flexed part of the loop in this species (see Kott 2001); and their position in *L. multitestis* does not constitute a distinction from other species of the Didemnidae. The confined atrial aperture (Monniot and Monniot 1996: fig 18A) is not found in other species of this genus, and appears to be too small to accommodate the ciliary current that would be generated by a branchial sac of the size indicated. There also are aspects of the figured larva (Monniot and Monniot 1996: 169, fig. 18E) that appear to be incorrect, *viz.* the turned back ectodermal ampullae, if turned forwards, would over-reach the incongruously short-stalked adhesive organs and obstruct their contact with the substrate; and although it is stated that there are no blastozooids, there is no evidence that they do not develop following further differentiation of the oozoid. Nevertheless, there are size-related characters that distinguish *L. multitestis* from the present species. The branchial sac has twice the number of stigmata per row, and the zooid and larval trunk are each twice the size of the present species. The living colony looks different from the present species. The retractor muscle has not been reported in *L. multitestis* but may be present; nor have the spherical cells in the test been reported.

### *Diplosoma translucidum* (Hartmeyer, 1909)

(Figs 27F, G, ?H)

*Leptoclinum translucidum* Hartmeyer, 1909: 1490 (nom. nov. for *Leptoclinum perspicuum* Sluiter, 1909: 79).

*Diplosoma translucidum* - Kott 2001: 343 and synonymy.

**Records.** *New record:* Northern Territory (Darwin, Navy Base Rock Wall, NTM E160, ?E163). *Previously recorded* (see Kott 2001): NW Australia, Queensland, Indonesia, New Caledonia.

**Description.** The newly recorded, translucent, whitish colony is growing around tangled fishing line. The relatively small zooids are in clumps anchored to the basal test by short connectives. Thoraces are held close to the surface test by short branchial siphons. Larvae, present in the colony collected in September (NTM E160), have an oozoid and a blastozooid in the anterior part of the 0.6 mm long trunk and two pairs of ectodermal ampullae. Whitish spherical cells were observed, packed in the test around zooids and larvae. However these were not detected in the scanning electron micrographs.

The colony (NTM E163) questionably assigned to this species has a characteristic colony, white in life with small zooids attached to the surface test by short branchial siphons and to the basal test by relatively short connectives which have two or three branches or are

unbranched (each zooid being in a separate strand of test between the basal and surface test). In preservative, however, this colony is dark plum-coloured throughout, the test containing orange to brown spherical cells crowded around and obscuring the zooids. These pigment cells (which resemble the pigment cells in *Lissoclinum badium*) are beneath the layer of white cells in the surface test. Their significance is not understood. The colony is white in life.

**Remarks.** The plum-coloured colony superficially resembles colonies of *Diplosoma ferrugineum* (Kott, 2001) and has the characteristic clumps of small zooids in tough translucent test. However it has smaller zooids, shorter, less branched basal test connectives and larvae have a shorter trunk than recorded for *D. ferrugineum*. Further, although the white cells crowded in the test around the zooids and larvae superficially resemble the morulae in *D. ferrugineum*, they do not appear to be homologous.

### *Diplosoma virens* (Hartmeyer, 1909)

*Leptoclinum virens* Hartmeyer, 1909: 145.

*Diplosoma virens* - Kott 2001: 347 and synonymy.

*Diplosoma pavonia* - Monniot and Monniot 2001: 278.

**Records.** *New record:* Northern Territory (Port Essington, NTM E29). *Previously recorded* (see Kott 2001): NE, NW Australia and Northern Territory (Darwin, Cape Don); western Pacific and Indian Ocean.

**Remarks.** The newly recorded colonies are tough cushions to 3 cm long, forming a mosaic around coral rubble.

### ACKNOWLEDGMENTS

The work on this paper was done while the author was the recipient of a grant from the Australian Biological Resources Study (ABRS). With the exception of the *in situ* photograph of *Clavelina amplexa* (Fig. 21B, Neville Coleman), the photos showing the colour varieties of *Sycozoa seiziwadai* (Fig. 22, photos courtesy of Shallow Water Marine Collection Taxonomy Program, US National Cancer Institute) and the deck photograph of *T. marmoratum* (Fig. 26B, AIMS Bioactivity Group), all of the colour images reproduced in this work are *in situ* photographs taken by Karen Gowlett Holmes, who also was responsible for the carefully documented collection on which the study is primarily based. I am also grateful to the Museum and Art Gallery of the Northern Territory, Dr Phil Alderslade and collections manager Gavin Dally for the opportunity to examine and report on the material. Daniel Schmidt has helped with many aspects of the work, and has produced the scanning electron micrographs and other figures that illustrate this paper.

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Accepted 2 July 2002

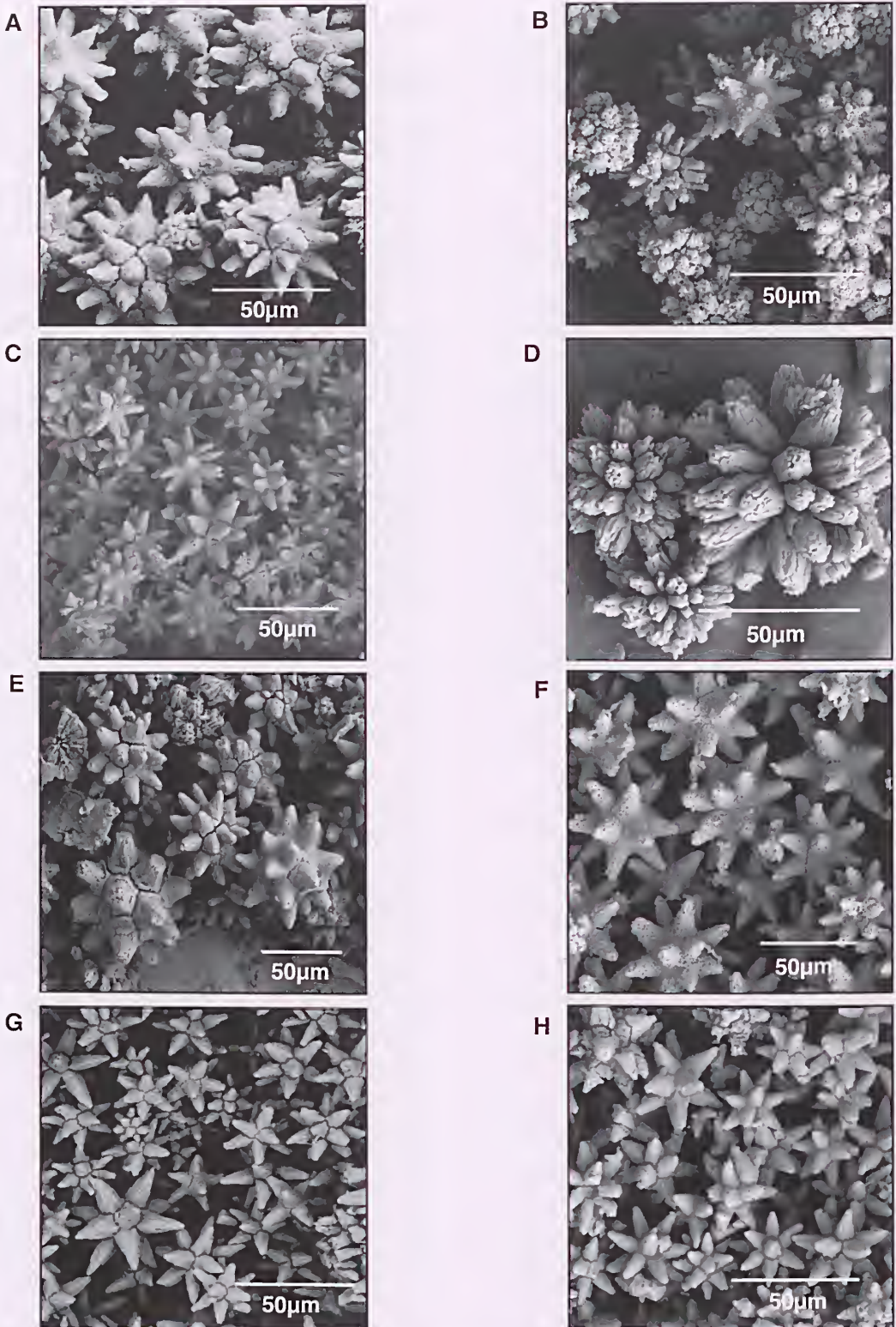
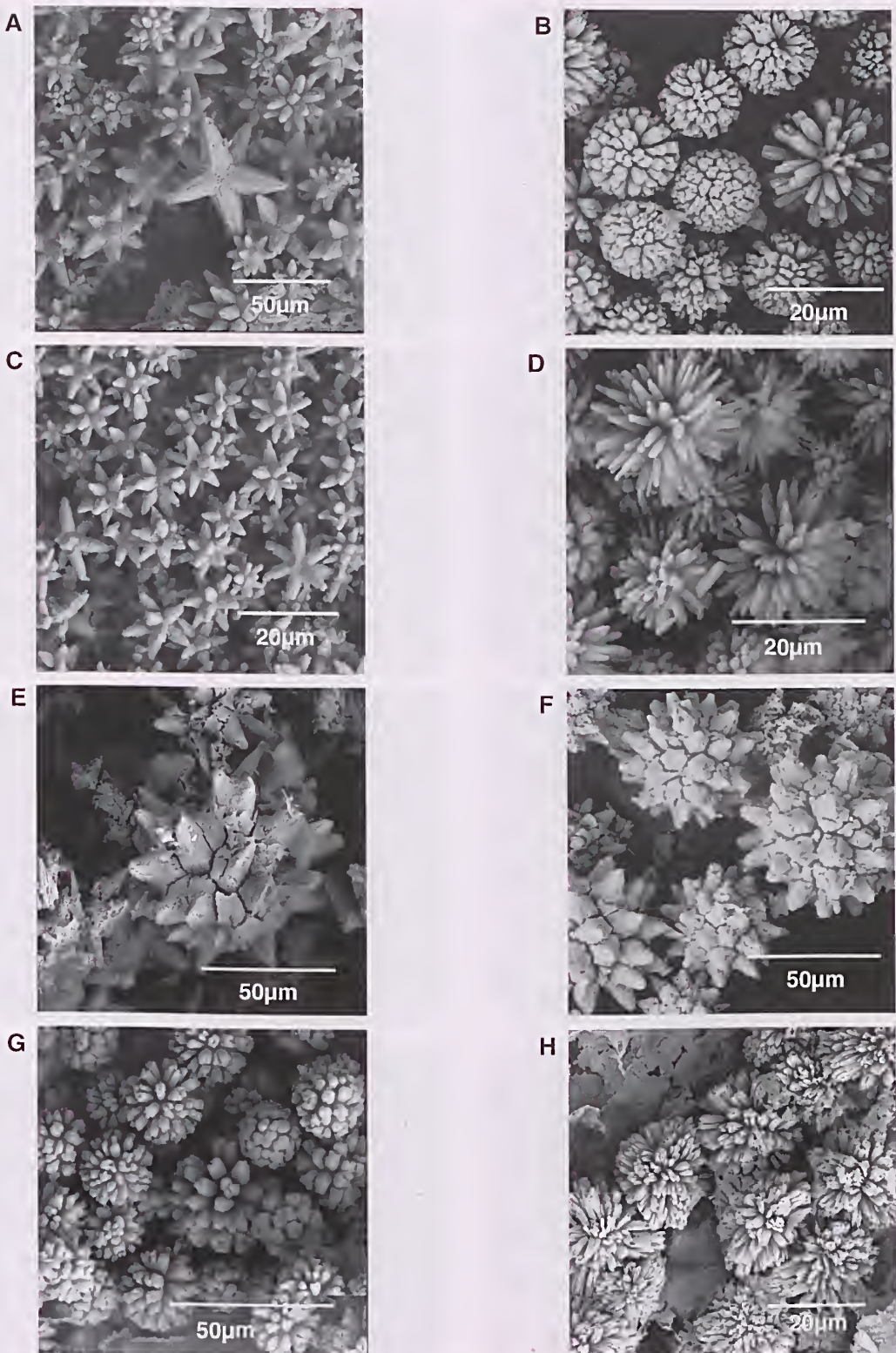


Fig. 19. Scanning electron micrographs of calcareous spicules from the test of A, *Leptoclinides aciculus* (NTM E185); B, *Leptoclinides complexus* (NTM E13 holotype); C, *Polysyncraton cuculliferum* (ZMA TU490 holotype); D, *Polysyncraton dronide* NTM (E211); E, *Polysyncraton pavimentum* (NTM E170); F, *Polysyncraton pseudorugosum* (NTM E21); G, *Didennium clavum* (NTM E158); H, *Didennium madeleineae* (NTM E230).





**Fig. 20.** Scanning electron micrographs of calcareous spicules from the test of **A**, *Didemnum membranaceum* (*D. turritum* Michaelson, 1930, ZMH T1701 syntype); **B**, *Didemnum parau* (NTM E153); **C**, *Didemnum perplexum* (NTM E206); **D**, *Didemnum psammatoide* (QM G303655); **E**, *Trididemnum marmoratum* (QM G308587); **F**, *Trididemnum planum* (NTM E192); **G**, *Lissoclinum conchylum* (NTM E221); **H**, *Lissoclinum limosum* (NTM E182).



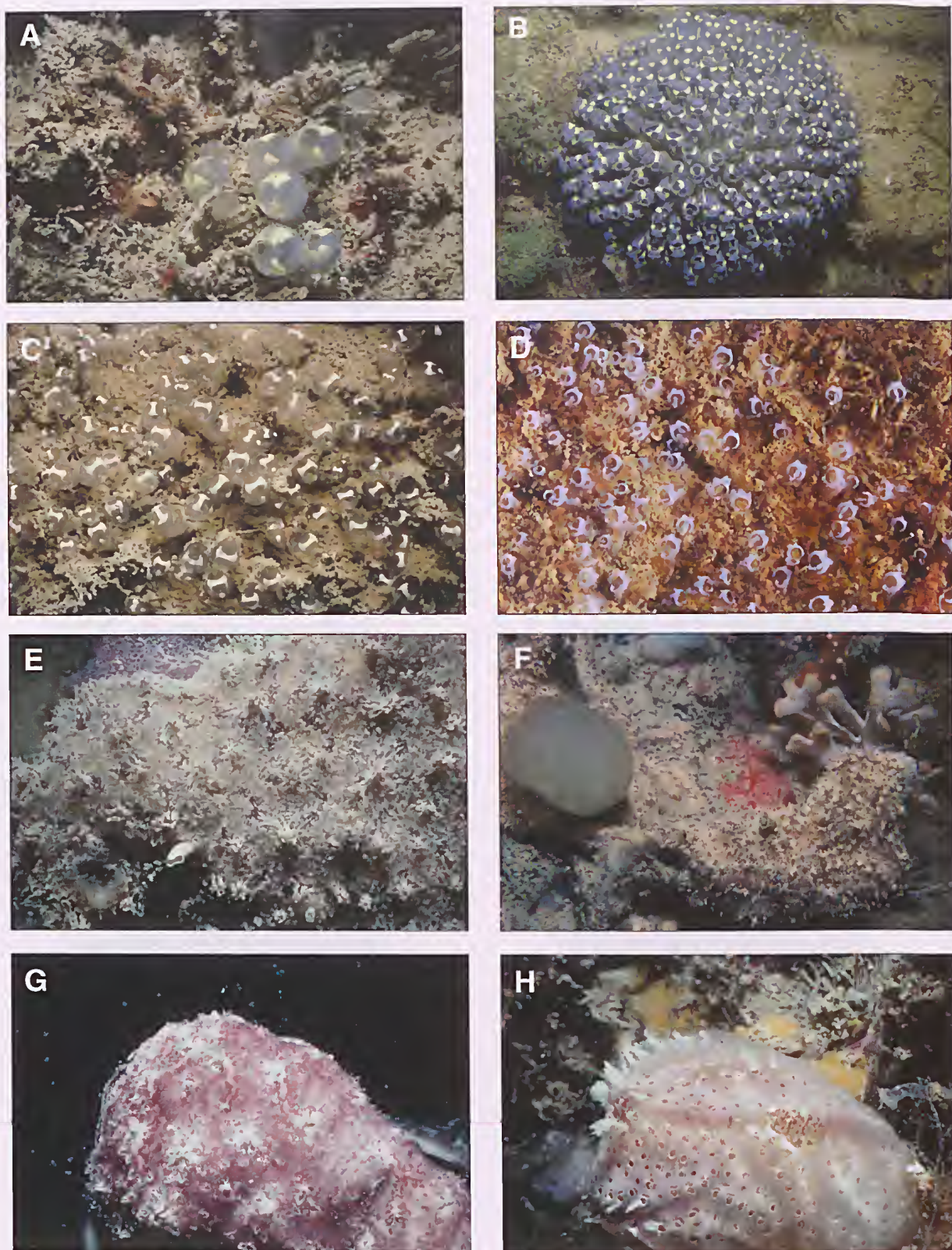


Fig. 21. A, B, *Clavelina amplexa* – A (NTM E155 holotype); B whole colony from East Point, Darwin; C, *Clavelina oliva* (NTM E176); D, *Pycnoclavella diminuta* (NTM E220); E, F, *Distaplia cuspidis* (NTM E198 paratype, E200); G, H, *Distaplia mikropnoa* (NTM E199, E200).



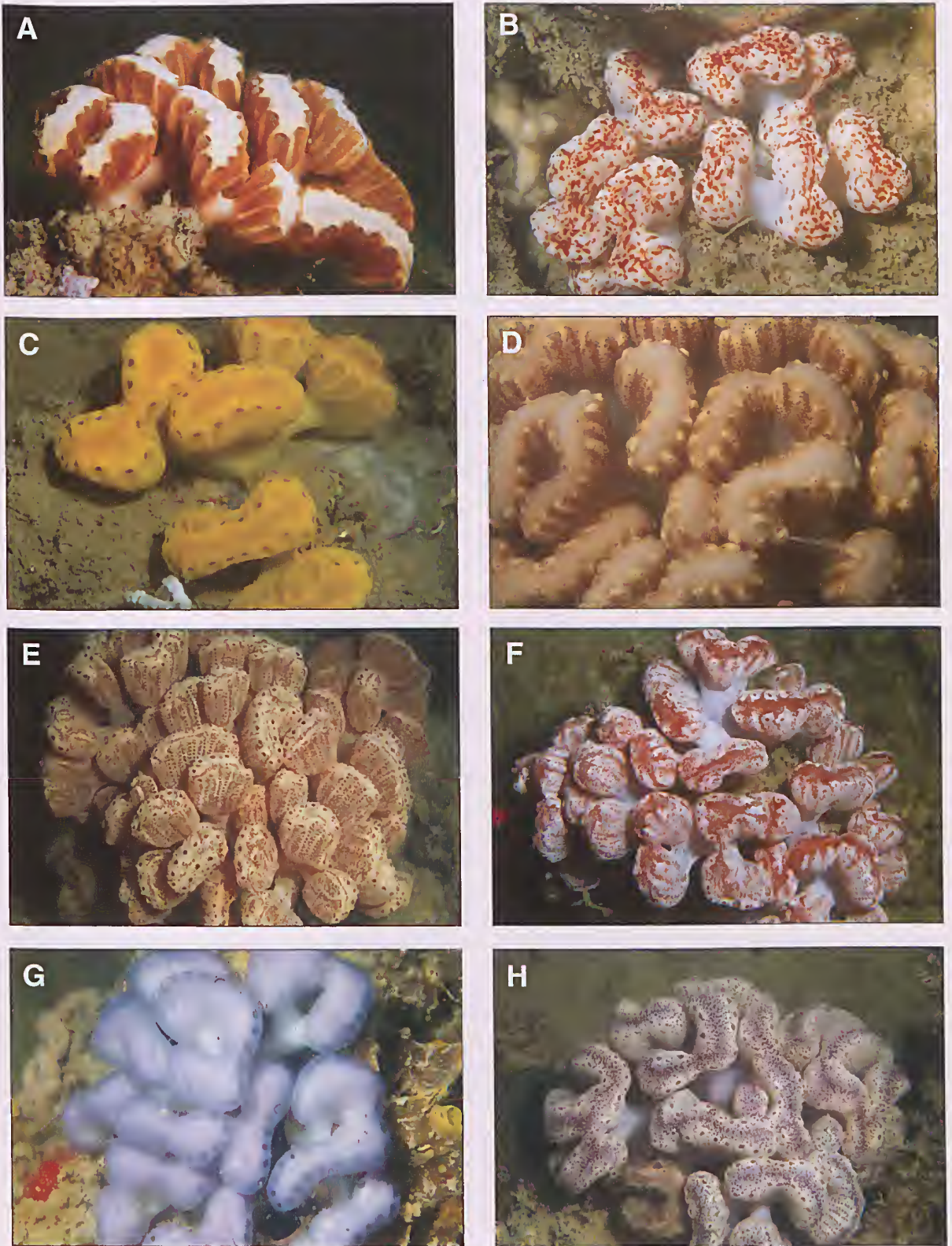


Fig. 22A–H. *Sycosoa seiziwadae* showing colour variations.



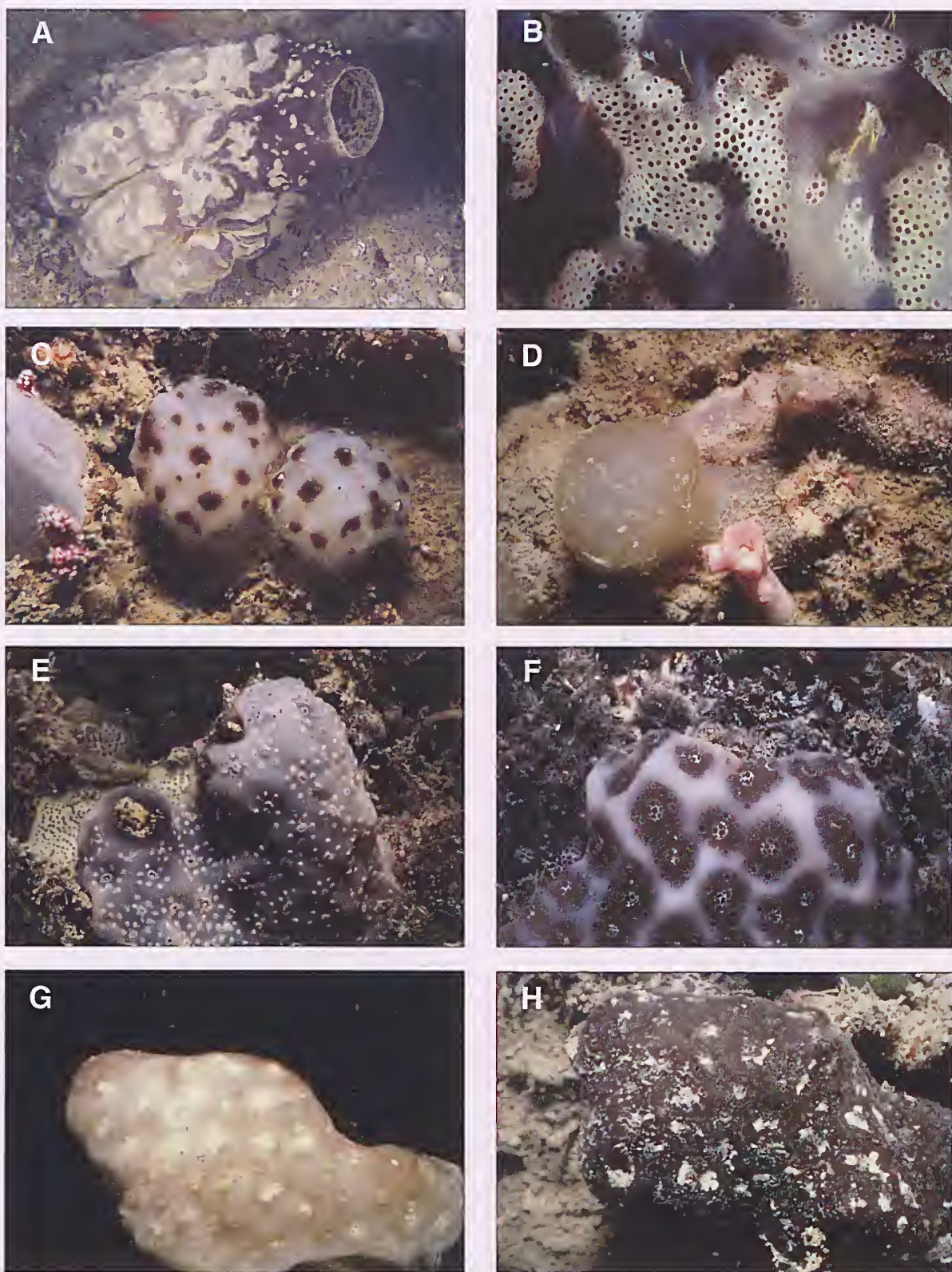


Fig. 23. A, B, *Hypodistoma deerratum* (NTME216); C, D, *Polycitor circes* (NTME179, E180); E, F, *Eudistoma eboreum* (NTME213); G, *Eudistoma superlatum* (NTME156); H, *Cystodytes philippinensis* (NTME157).



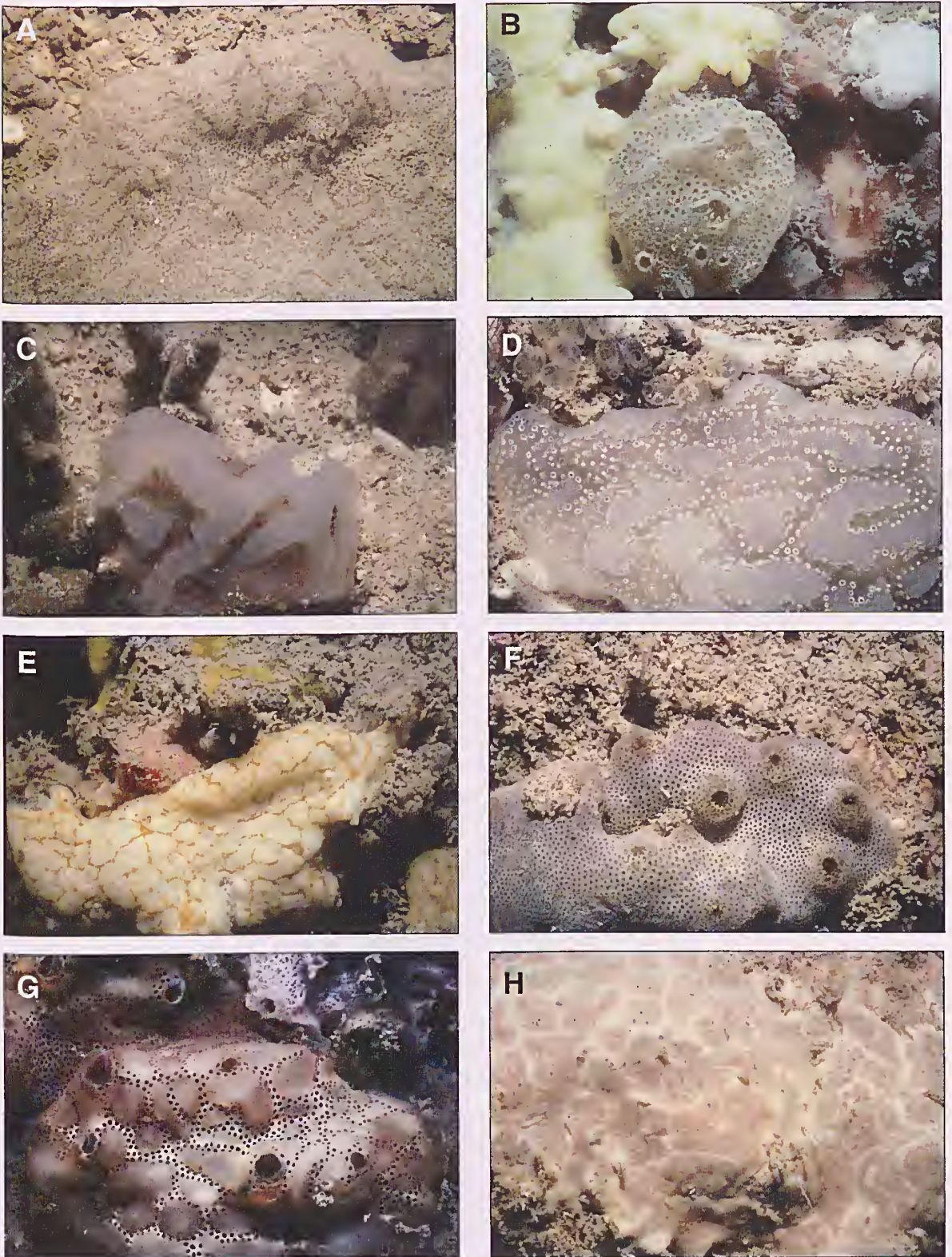


Fig. 24. A, B, *Synoicum macroglossum* (NTM E168, E202); C, *Aplidium grisiatum* (NTM E151); D, *Aplidium multiplicatum* (NTM E169); E, *Leptoclinides aciculus* (NTM E159); F, *Polysyncraton cuculliferum* (NTM E174); G, *Polysyncraton dromide* (NTM E154); H, *Polysyncraton pavimentum* (NTM E170).



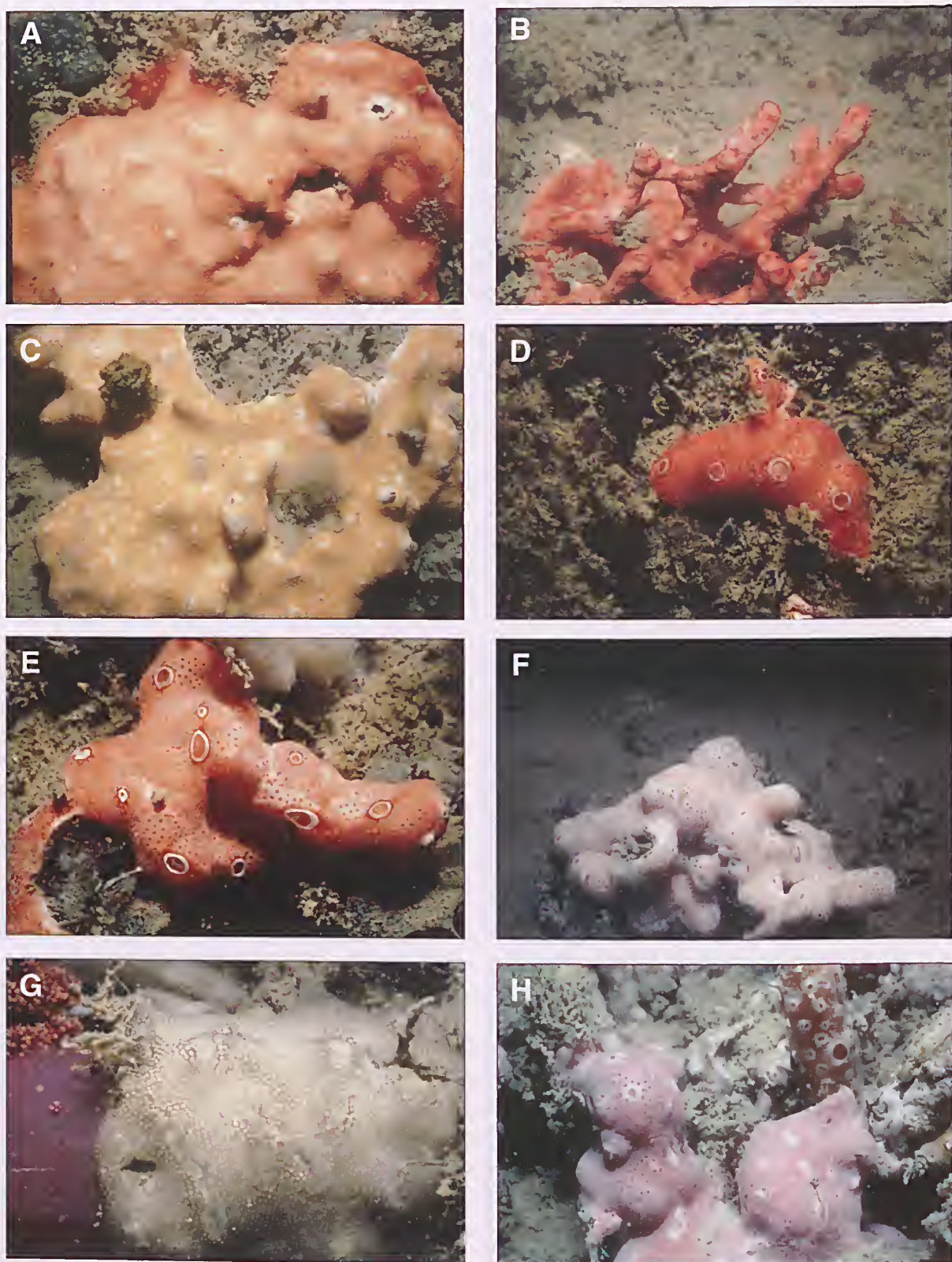


Fig. 25. A, B, *Didemnum clavum* (NTM E150, E183); C, *Didemnum granulatum* (NTM E152); D-F, *Didemnum madeleineae* (NTM E178, E184, E203); G, *Didemnum parva* (NTM E153); H, *Didemnum perplexum* (NTM E206).



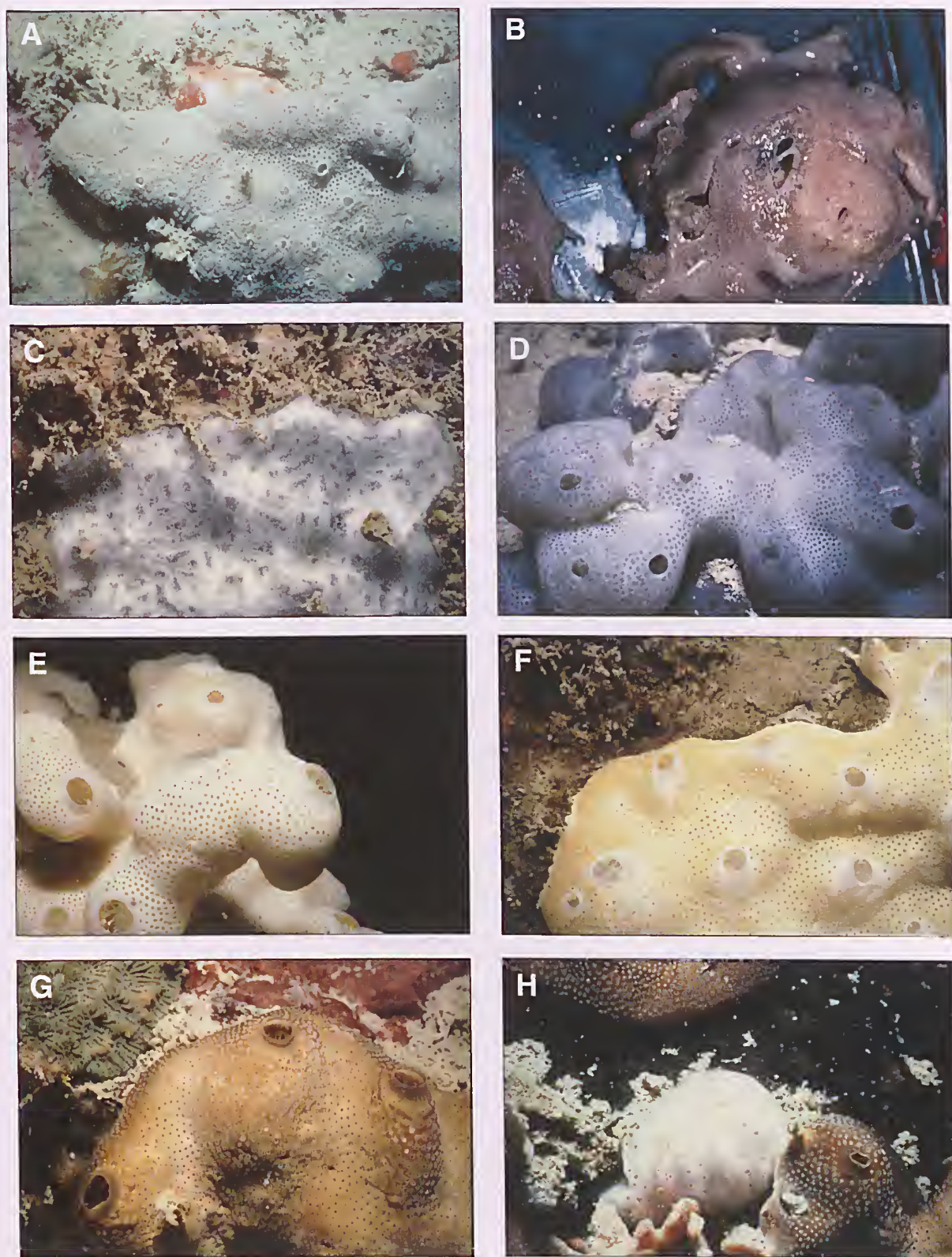


Fig. 26. A, *Dideunum psammotode* (NTM 207); B, *Trididemnum marmoratum* (deck photo, QM G308587); C, *Trididemnum planum* (NTM E191); D, *Trididemnum savignii* (NTM E214); E-H, *Lissoclinum badium* (NTM E173, E190, E186, E189 brown colonies).



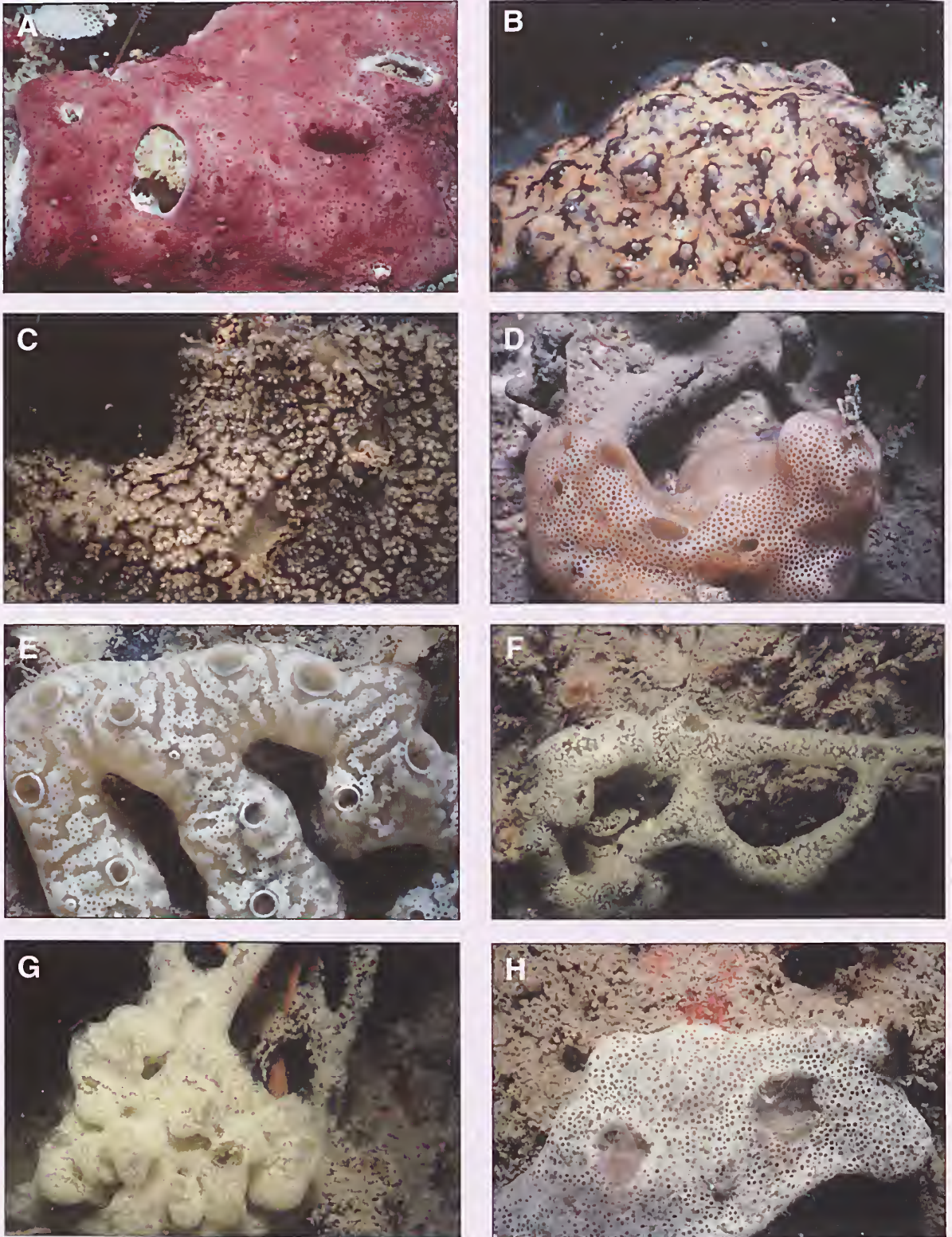


Fig. 27. A, *Lissoclinum conchylum* (NTM E221); B, *Lissoclinum durable* (NTM E204); C, *Lissoclinum lutosum* (NTM E182); D, E, *Lissoclinum multifidum* (NTM E210, E212); F, G, *Diplosoma translucidum* (NTM E160); H, ?*Diplosoma translucidum* (NTM E163).



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## B

*badium*, *Lissoclinum* 21, 40, 43, **53**  
*bistratum*, *Lissoclinum* 21

## C

*capitata*, *Ascidia* 21  
*captivum*, *Didemnum* 36  
*cerebriforme*, *Aplide* 26  
*cerebriformis*, *Sycozoa* 25  
*circes*, *Polycitor* 20, 26, **50**  
*Clavelina* 21, 22  
*Clavelina* (see *amplexa*, *arafurensis*,  
*fecunda*, *oliva*, *robusta*)  
*Clavelinidae* 21  
*clavum*, *Didemnum* 20, 21, 35, 38, **46**, **52**  
*Cnemidocarpa areolata* 21  
*comitus*, *Leptoclinides* 30  
*complexus*, *Leptoclinides* 29, **46**  
*complexus* sp. nov., *Leptoclinides* 30  
*concavum*, *Lissoclinum* 42  
*conchylum*, *Lissoclinum*  
21, 40, **41**, **47**, **54**  
*cristatum*, *Trididemnum* 39  
*cuculliferum*, *Didemnum* 30, 31  
*cuculliferum*, *Diplosomoides* 30  
*cuculliferum*, *Polysyncrator*  
20, 30, 31, 36, **46**, **51**  
*cuspidis*, *Distaplia* 23, 24, **49**  
*cuspidis* sp. nov., *Distaplia* 23  
*cyclops*, *Trididemnum* 21  
*Cystodytes philippinensis* 20, 27

## D

*deerrata*, *Distoma* 26  
*deerratum*, *Hypodistoma* 20, 26, **50**  
*Didemnidae* 29  
*Didemnum* 30, 32, 35, 36, 37, 38, 39  
*Didemnum* (see *albopunctatum*, *algasedens*,  
*captivum*, *clavum*, *cuculliferum*, *fragile*,  
*fuscum*, *granulatum*, *litlostrotum*,  
*madeleineae*, *membranaceum*, *molle*,  
*moseleyi*, *granulatum*, *multispirale*,  
*parau*, *perplexum*, *psammotode*,  
*ramosum*, *savignii*, *sibogae*, *sordidum*,  
*turritum*)  
*diminuta*, *Clavelina* 22  
*diminuta*, *Pycnoclavella* 20, 22, **49**  
*diminutum*, *Archidistoma* 22  
*Diplosoma* 43  
*Diplosoma* (see *ferrugineum*, *pavonia*,  
*translucidum*, *virens*)  
*Diplosomoides* 30, 36, 37  
*discrepans*, *Trididemnum* 39  
*Distaplia* (see *cuspidis*, *mikropnoa*,  
*racemosa*, *regina*, *stylifera*)

*dromide*, *Polysyncrator*

20, 31, 32, 34, **46**, **51**  
*dubium*, *Archidistoma* 22, 23  
*durabile*, *Lissoclinum* 21, 41, **54**

## E

*eboreum*, *Eudistoma* 20, 27, **50**  
*eclinatum*, *Polysyncrator* 30  
*Ecteinascidia diaphanis* 21  
*Eudistoma* (see *eboreum*, *superlatum*)  
*exasperatus*, *Microcosmus* 21

## F

*fascicularis*, *Nephtheis* 20  
*fecunda*, *Clavelina* 22  
*ferrugineum*, *Diplosoma* 43  
*fragile*, *Didemnum* 37  
*fuscum*, *Didemnum* 37

## G

*granulatum*, *Didemnum* 21, 35, **52**  
*griseum*, *Aplidium* 28  
*grisiatum*, *Aplidium* 20, 28, **51**

## H

*Holozoidae* 23  
*Hypodistoma* 26  
*Hypodistoma deerratum* 20

## L

*Leptoclinides* 29, 30  
*Leptoclinides* (see *aciculus*, *complexus*,  
*dubius* group, *madara*)  
*Leptoclinum* (see *perspicuum*, *psammathodes*,  
*translucidum*, *virens*)  
*limosum*, *Lissoclinum* 21, 42, **47**, **54**  
*Lissoclinum* 40, 42  
*Lissoclinum* (see *badium*, *bistratum*,  
*concavum*, *conchylum*, *durabile*,  
*limosum*, *multifidum*, *multitestis*)  
*litlostrotum*, *Didemnum* 32  
*litlostrotum*, *Polysyncrator* 32

## M

*Macroclinum* 28  
*macroglossum*, *Macroclinum* 28  
*macroglossum*, *Synocium* 20, 28, **51**  
*madara*, *Leptoclinides* 29  
*madeleineae*, *Didemnum*  
21, 35, 36, 38, **46**, **52**  
*marmoratum*, *Leptoclinum* 38  
*marmoratum*, *Trididemnum*  
20, 21, 38, **47**, **53**  
*membranaceum*, *Didemnum* 21, 36, **47**  
*membranaceum*, *Diplosomoides* 36  
*Microcosmus exasperatus* 21  
*mikropnoa*, *Distaplia* 20, 24, **24**, **49**  
*mikropnous*, *Polycyclium* 24  
*millari*, *Phallusia* 21  
*molle*, *Didemnum* 20, 21, 37  
*molle*, *Diplosomoides* 37  
*moseleyi*, *granulatum*, *Didemnum* 35  
*multifidum*, *Lissoclinum* 21, **41**, **42**, **54**  
*multiplicatum*, *Aplidium* 20, 29, **51**  
*multispirale*, *Didemnum* 36  
*multitestis*, *Lissoclinum* 42

## N

*nekozita*, *Didemnum* 31, 36  
*Nephtheis fascicularis* 20

## O

*oliva*, *Clavelina* 20, 22, **49**

## P

*palliolum*, *Polysyncrator* 34  
*papillata*, *Polycarpa* 21  
*parau*, *Didemnum* 21, 37, **47**, **52**  
*pavimentum*, *Polysyncrator*  
20, 21, 32, **33**, **46**, **51**  
*pavonia*, *Diplosoma* 43  
*Perophoridae* 21  
*perplexum*, *Didemnum* 21, 35, 37, **47**, **52**  
*perspicuum*, *Leptoclinum* 43  
*Phallusia millari* 21  
*philippinensis*, *Cystodytes* 20, 27, **50**  
*planum*, *Trididemnum* 21, 39, **40**, **47**, **53**  
*Polycarpa papillata* 21  
*Polycitor* 26  
*Polycitor circis* 20, 26  
*Polycitoridae* 26  
*Polyclinidae* 28  
*Polyclinum mikropnous* 24  
*Polysyncrator* (see *arafurensis*,  
*aspiculatum*, *cuculliferum*,  
*dromide*, *eclinatum*, *palliolum*,  
*pavimentum*, *pseudorugosum*, *purou*,  
*vestiens*)  
*psammathodes*, *Leptoclinum* 38  
*psammotode*, *Didemnum* 21, 38, **47**, **53**  
*pseudorugosum*, *Polysyncrator* 21, 33, **46**  
*purou*, *Polysyncrator* 21, 32, 33, **34**  
*Pycnoclavella diminuta* 20  
*Pycnoclavellidae* 22

## R

*racemosa*, *Distaplia* 23  
*ramosum*, *Didemnum* 39  
*regina*, *Distaplia* 23  
*regulum*, *Polysyncrator* 30  
*robusta*, *Clavelina* 21, 22

## S

*savignii*, *Didemnum* 39  
*savignii*, *Trididemnum* 20, 21, 39, **53**  
*seiziwadae*, *Sycozoa* 25  
*seiziwadae*, *Sycozoa* 20, 25, **49**  
*sibogae*, *Didemnum* 39  
*sibogae*, *Trididemnum* 21, 38, 39, **40**  
*sordidum*, *Didemnum* 37  
*stylifera*, *Distaplia* 25  
*superlatum*, *Eudistoma* 20, 27, **50**  
*Sycozoa* (see *cerebriformis*, *seiziwadae*,  
*seiziwadae*, *sigillinoides*)  
*sydneiensis*, *Ascidia* 21  
*Synocium macroglossum* 20

## T

*translucidum*, *Diplosoma* 21, 43, **54**  
*translucidum*, *Leptoclinum* 43  
*Trididemnum* 38, 39  
*Trididemnum* (see *cristatum*, *cyclops*,  
*marmoratum*, *planum*, *savignii*, *sibogae*)  
*turritum*, *Didemnum* 31, 36

## V

*vestiens*, *Polysyncrator* 32  
*virens*, *Diplosoma* 20, 21, 43  
*virens*, *Leptoclinum* 43





## The Angalarri grunter, *Scortum neili* Allen, Larson and Midgley (Teleostei: Terapontidae): description of adults and their habitat

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### ABSTRACT

Fourteen mature specimens of the Angalarri grunter (*Scortum neili* Allen, Larson and Midgley) were collected from the main headwater tributary of the Angalarri River in the Victoria River system, Northern Territory, seventeen years after its original discovery at this site in 1981. The distinctive habitat features of this stretch of river include deep (5–6 m), wide (>10 m) pools with closed dense canopy, submerged and exposed fringing tree roots, and an algal-covered substrate mostly comprising pebbles to very large rocks and rock ledges with crevices. *Scortum neili* were common and appear to be confined to this particular river stretch where they were seen in schools of up to twenty-five individuals, often in association with other fishes including Jenkins' grunter (*Hephaestus jenkinsi*). Remains of algae and other vegetation in stomachs together with the size and shape of the gut suggests that this species is primarily a herbivore/detritivore. Counts of fin rays, scales and gill rakers were consistent with the type material except that up to 24 transverse scales below the lateral line were counted on the specimens collected from this survey, compared with a maximum count of 21 in the holotype and paratype specimens. Differences in several proportional measurements between the specimens collected in this survey and the relatively smaller paratypes could be accounted for by ontogenetic growth.

KEYWORDS: Angalarri grunter, *Scortum neili*, Teleostei, Terapontidae, description, habitat.

### INTRODUCTION

The Angalarri grunter (*Scortum neili*) is a relatively small terapontid fish, reaching 243 mm standard length. It is uniformly silvery grey with 0–5 randomly distributed black blotches on each side (Fig. 1) and, on freshly captured specimens, about 10 pale vertical bars on each side.

*Scortum neili* was described on the basis of 10 paratypes from a single location in an upper tributary of the Angalarri River in 1981 (Midgley 1981), and from the holotype, collected from Limestone Gorge, East Baines River in 1986 (Allen *et al.* 1993). Both rivers are in the Victoria River system within the Timor Sea drainage. To date, the species has not been recorded beyond these two rivers.

The entire catchment of the Angalarri River is currently managed by the Department of Defence as part of the Bradshaw Field Training Area (BFTA). During baseline surveys of BFTA, *Scortum neili* was not recorded in the lower reaches of the Angalarri River, or in any of the other waterbodies surveyed at BFTA (Corbett 1997). This paper outlines the results of a survey of the same tributary from which Hamar

Midgley collected the original *Scortum neili* specimens in 1981 (Midgley 1981).

The relatively large size of specimens sampled during this survey provided an opportunity to investigate the influence of body length/age on body proportions, by comparing measurements with the smaller paratype specimens described in Allen *et al.* (1993).

### METHODS

#### Site location, sampling dates and techniques.

Sampling was conducted on 23–24 September 1998 (late dry season) along a stretch of the main headwater tributary of the Angalarri River. The main sampling site was accessed with land vehicles and an assessment of the broad characteristics of the Angalarri River and other BFTA rivers was conducted by helicopter.

The main survey pool (14°59'12"S, 130°55'23"E) of about 1.5 km long was located about 20–25 km downstream from the Angalarri River headwaters in the Barwolla Range (Fig. 2). There were several similar pools in this stretch of river, of which one was Midgley's original collection site (approx. 14°59'S, 130°56'E).



Fig. 1. The Angalarri grunter (*Scortum neili*). Note the dark lateral blotches. Although this photograph was taken soon after capture, the thin light vertical bars have already faded (L. Corbett).

All specimens were captured in gill nets (20 m long, 2 m drop, multi-panelled with mesh sizes 76, 100, 126 and 150 mm), set in various depths for up to one hour in the mid-afternoon. This procedure was conducted to minimise capture of freshwater crocodiles (*Crocodylus johnstoni*) that were attracted to fishes in the net. Crocodiles that were inadvertently captured were released unharmed. Other techniques including seine netting, dip netting, fishing with baited lines and lures, and spotlighting were unsuccessful in capturing or observing *Scortum neili*. A collection of fourteen *Scortum neili* specimens (NTM S.14753-001), as well as voucher specimens of other species captured are currently housed at the Museum and Art Gallery of the Northern Territory.

**Habitat characteristics.** The habitat of *Scortum neili* was assessed in terms of water quality, stream structure and fringing riparian vegetation.

*In situ* water quality parameters measured were electrical conductivity, pH, turbidity, dissolved oxygen, and water temperature, using a Horiba (U-10) water quality checker (laboratory calibrated) at two sites along the main survey pool. These parameters were measured at the water subsurface, and over the entire water column (0.5 m intervals from surface to bottom), in order to assess the degree of mixing of the water column. The depth of light penetration was measured with a Secchi disc.

Other qualitative habitat parameters that were estimated included details of stream structure (length,

width, depth), flow and substrate characteristics; degree of shading (% shade at noon); density and composition of riparian and aquatic vegetation; relative abundance of potential food resources (e.g. aquatic invertebrates); and relative abundance of crocodiles (presumed predators).

**Diet and anatomical description.** The stomach and intestinal tracts (guts) of five *Scortum neili* specimens were examined under a dissecting microscope to assess diet and gut morphology. These specimens comprised large and small individuals that had been held in gill nets for up to one hour. Measurements and counts of anatomical features followed the methodology of Hubbs and Lagler (1970) and the format and terminology used in describing these features followed Vari (1978).

## RESULTS

**Species present.** Thirteen fish species in addition to *Scortum neili* were recorded, including six taxa that were not recorded in Midgley's original survey of this Angalarri River locality (Table 1).

*Scortum neili* appeared to be common at this site, with over fifty specimens sighted; twenty-seven were captured of which fourteen were retained as voucher specimens. The longest measured specimen was 243 mm SL. However, some individuals observed at close range were clearly larger than fish in the nets, and were estimated as 350–400 mm SL. *Scortum neili* were



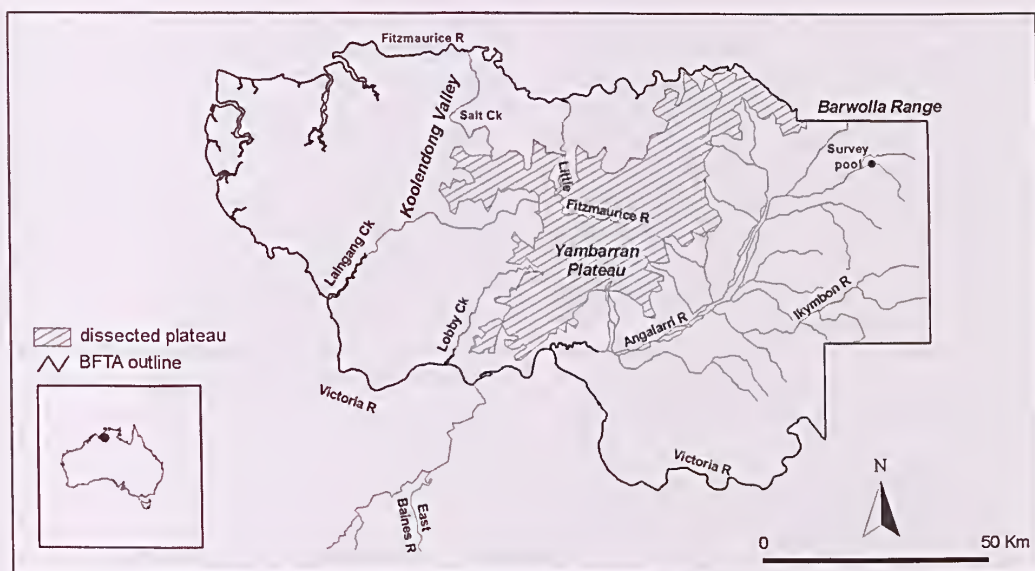


Fig. 2. Bradshaw Field Training Area and location of place names (L. Corbett).

observed singly or in schools of up to twenty-five individuals, which were frequently interspersed with schools of the terapontid *Hephaestus jenkinsi* (Jenkins' grunter). *Scortum neili* was only observed and captured at depths of 2–5+ m and usually amongst undercut banks and tangled roots of submerged riparian vegetation; suggesting that it prefers deeper sheltered habitats during the day.

**Habitat characteristics.** The Angalarri River is characterised by deep shaded pools within a deep gorge in its upper reach (about 30 km long) before dissipating

into a series of braided channels in its middle reaches that are dry for many months. The river then receives a major tributary (Ikymbon River) to reform in its lower tidal reaches before joining the Victoria River (Fig.2)

At the sampling site in the upper reach, the river was in a gorge about 25–30 m wide. At the time of sampling the water level was about 10 m below the top of the gorge. The main survey pool was about 1.5 km long with a maximum width of 20 m and a minimum width at the inflow/outflow ends of about 3 m. Depth ranged from about 0.1 m to 5–6 m. No turbulence or flow was detected by eye within the main body of the pool, however minor flow was evident over the shallow rocky extremities of the pool.

Water quality was fairly uniform throughout the depth profile of the main pool, even at depths of 5 m. Turbidity was very low with a turbidity value of 1 NTU (Nephelometric Turbidity Unit) and Secchi disk depths of up to 4.6 m recorded. Electrical conductivity varied little around 41  $\mu\text{Scm}^{-1}$  ( $S$  = Siemens) and pH was slightly alkaline (7.9–8.2). Water temperature varied no more than 1.5°C across a 5 m depth profile (average 27.8°C). Dissolved oxygen varied with depth more than other variables, with a concentration of 4.35 mg/L at the sub-surface, decreasing steadily to a value of 0.93 mg/L at a depth of 5.0 m.

The stream substrate up to 5 m depth was comprised almost entirely of small pebbles to very large rocks (diameter range about 0.03–>10 m). Substrate composition at depths >5 m was not investigated. Substantial rock ledges and crevices were also present in the main survey pool. The small amount of substrate detritus that was evident was mostly the leaves of overhanging trees, *Pandanus aquaticus* and *Melaleuca*

Table 1. Fish species identified at the site in addition to *Scortum neili*.

Species	Common Name	Number Captured
<i>Megalops cyprinoides</i>	Ox-eye herring	5
<i>Nematalosa erebi</i>	Bony bream	4
<i>Arius graeffei</i> * †	Fork-tailed catfish	55
<i>Neosilurus ater</i>	Black eel-tailed catfish	5
<i>Melanotaenia splendida australis</i>	Red-tailed rainbowfish	37
<i>Ambassis agrammus</i> *	Sailfin glass-perchlet	3
<i>Parambassis gulliveri</i> * †	Giant glass-perchlet	9
<i>Amniataba percoides</i> *	Barred grunter	24
<i>Hephaestus jenkinsi</i> †	Jenkins' grunter	23
<i>Leiopotherapon unicolor</i> †	Spangled grunter	20
<i>Toxotes chatareus</i> †	Common archerfish	16
<i>Liza alata</i> *	Diamond mullet	5
Undetermined species *	Goby	1

\* Species not recorded in association with *Scortum neili* on the Angalarri River in the original species description (Allen et al. 1993).

† Voucher specimens deposited in the Museum and Art Gallery of the Northern Territory.

*argentea*, and there were several dead tree branches. No aquatic macrophytes, other than *Pandanus aquaticus* were recorded in the main survey pool, or at nearby upstream and downstream pools. However, algae formed a thick mat-like layer (up to about 5 mm) on all rocky substrates.

Riparian vegetation, about 5 m wide on both banks, was dominated by *Melaleuca argentea*. Other vegetation included *Ficus racemosa*, *Nauclaea orientalis* and *Pandanus aquaticus*. The summation of all riparian vegetation provided a stream shade cover of 35–45% at 12 noon. There were extensive areas of submerged, exposed roots of riparian vegetation along both banks.

Aquatic insects were abundant, especially water

striders (Gerridae) and damselflies (Zygoptera). Freshwater prawns (*Macrobrachium* sp.) and freshwater mussels (*Velesunio* sp.) were common, and twelve freshwater crocodiles were recorded in the main pool.

**Diet.** The stomach and intestine (gut) contents of five *Scortum neili* specimens were examined. All specimens contained algae, either filamentous algae in sections up to 5 mm long (two guts) or a gelatinous algal mass, possibly partly digested filamentous algae (two guts) or both (one gut). All guts included a relatively small amount of detritus (unidentified vegetation). One stomach included several large *Ficus* fruit and another intestine included a small insect exoskeleton (unidentified species).

**Table 2.** Comparison of anatomical measurements and counts between specimens collected in this survey and those described in Allen *et al.* (1993).

	Holotype n=1	Paratypes n=10	This survey n=14
Standard Length (SL) mm	220	73.5–86.8	144–243
<b>Measurements in SL:</b>			
Head Length	3.4	2.9–3.1	3.0–3.3
Maximum body depth	2.7	2.8–3.0	2.5–3.0
Dorsal origin to snout	2.7	2.5–2.6	2.6–2.9
Base of dorsal fin	1.8	1.7–1.8	1.6–1.7
<b>Measurements in Head Length:</b>			
Snout length	3.3	3.5–3.8	3.0–3.8
Eye width	5.2	3.5–4.2	4.7–6.1
Interorbital width	3.2	3.1–3.5	2.7–3.0
Maxillary length	3.4	3.3–3.6	3.4–5.0
Longest (5th) dorsal spine	2.5	1.7–2.1	1.8–2.3
Longest (1st–6th) soft dorsal rays	2.2	2.0–2.4	1.9–2.5
Longest (2nd) anal spine	2.0	1.6–1.8	2.1–2.8
Longest (1st or 2nd) soft anal ray	2.0	1.9–2.2	2.2–2.5
Pectoral fin, length	1.4	1.5–1.7	1.5–1.6
Pelvic fin, length	1.3	1.4–1.6	1.3–1.4
Caudal fin, length	1.1	1.2–1.4	1.0–1.2
Min depth caudal peduncle	2.5	2.9–3.2	2.3–2.7
Caudal peduncle, length	1.9	1.7–2.0	1.5–1.9
<b>Counts:</b>			
<b>a) Fins</b>			
Anal rays	III, 9	III, 7–9	III, 7–8
Dorsal rays	XIII, 11	XIII, 9–12	XIII, 10–12
Pectoral rays	16	16–17	15–16
Pelvic rays	1,5	1,5	1,5
<b>b) Scales</b>			
Longitudinal above lateral line	73	62–73	64–72
Tubed lateral–line	52	49–52	49–52
Transverse above lateral–line	10	9–11	10–11
Transverse below lateral–line	20	17–21	21–24
Predorsal scales to occiput	18	18–20	18–21
Sheath scale rows dorsal base	3	1–3	2–3
Sheath scale rows anal base	4	3–4	3–4
Cheek scale rows	5	5–6	4–6
<b>c) Gill Rakers</b>			
Upper/lower limb	13 + 26	11–13 + 25–27	10–13 + 23–26
Total	39	36–40	33–39



All five specimens had long convoluted intestines, about 5–6 times the length of the stomachs. This gut morphology and the mostly vegetative gut contents suggests that *Scortum neili* is basically a herbivore/detritivore, as are other *Scortum* species (Vari 1978).

**Anatomical description.** Comparisons of morphometrics between the fourteen specimens collected in this survey and the ten specimens described in Allen *et al.* (1993) suggest that several *Scortum neili* anatomical proportions vary according to ontogenetic growth.

Counts of fin rays, scales and gill rakers were generally consistent between specimens in this survey as those for the holotype and paratypes (Table 2). The exception was that up to 24 transverse scales below the lateral line were counted on the specimens collected from this survey, compared with a maximum count of 21 in the holotype and paratype specimens. There were also some notable differences in proportional measurements between the specimens collected in this survey and the relatively smaller paratypes, whereas there was little difference from the similar-sized holotype.

Proportional measurements that were consistently (>50% of specimens) higher in larger specimens included head length, maximum body depth, snout length, caudal fin length and minimum depth of caudal peduncle. Eye width was the only measurement that consistently decreased with increasing body size, with all specimens from this survey having shorter eye widths than the paratypes but not the holotype (Table 2).

## DISCUSSION

The distribution of *Scortum neili* in BFTA appears to be limited to the Angalarri River and it may also be confined to the upper main tributary of the Angalarri River. It was not recorded during earlier baseline surveys at sites in the lower reaches of the Angalarri River, the Ikymbon River, Lobby Creek, Lalngang Creek, Salt Creek (North Koolendong Valley), the Little Fitzmaurice River or two unnamed streams on the Yambarran Plateau (Table 3, Corbett 1997, Fig. 2).

**Table 3.** List of fishes recorded from Bradshaw FTA during baseline surveys (Corbett 1997).

		Angalarri <sup>1</sup>	Koolendong <sup>3</sup>	Yambarran <sup>4</sup>
<i>Megalops cyprinoides</i> (Broussonet)	Ox-eye herring	X	X	X
<i>Nematalosa erebi</i> (Günther)	Bony bream	X	X	X
<i>Scleropages jardinii</i> (Saville-Kent)	Gulf saratoga	X		
<i>Arius graeffei</i> Kner and Steindachner	Fork-tailed catfish	X		
<i>Arius midgleyi</i> Kailola and Pierce	Shovel-nosed fork-tailed catfish	X		
Ariidae	Unidentified fork-tailed catfish		X	X
<i>Neosilurus hyrtlii</i> Steindachner	Yellow-finned eel-tailed catfish	X	X	
<i>Neosilurus ater</i> (Perugia)	Black eel-tailed catfish	X		
Plotosidae	Unidentified eel-tailed catfish			X
<i>Strongylura krefftii</i> (Günther)	Freshwater longtom		X	
<i>Melanotaenia splendida australis</i> (Castelnau)	Red-tailed rainbowfish	X	X	X
<i>Melanotaenia exquisita</i> Allen	Exquisite rainbowfish	X		
<i>Craterocephalus stercusmuscarum</i> (Günther)	Fly-specked hardyhead		X	X
<i>Ambassis agrammus</i> Günther	Sailfin glass-perchlet	X		
<i>Ambassis macleayi</i> (Castelnau)	Macleay's glass-perchlet	X	X	X
<i>Ambassis mulleri</i> Klunzinger	Muller's glass-perchlet			X
<i>Parambassis gulliveri</i> (Castelnau)	Giant glass-perchlet	X <sup>2</sup>		
<i>Lates calcarifer</i> (Bloch)	Barramundi	X	X	X
<i>Amniataba percoides</i> (Günther)	Barred grunter		X	
<i>Hephaestus jenkinsi</i> (Whitley)	Jenkins' grunter	X		X
<i>Leiopotherapon unicolor</i> Günther	Spangled grunter	X	X	X
<i>Scortum neili</i> Allen, Larson and Midgley	Angalarri grunter	X <sup>2</sup>		
<i>Syncomistes butleri</i> Vari	Butler's grunter	X		
<i>Glossamia aprion</i> (Richardson)	Mouth almighty	X	X	X
<i>Toxotes chatareus</i> (Hamilton-Buchanan)	Seven-spot archerfish	X	X	
<i>Liza alata</i> (Steindachner)	Diamond mullet		X	
<i>Glossogobius</i> n. sp.	Munro's goby	X		
<i>Mogurnda mogurnda</i> (Richardson)	Northern purple-spotted gudgeon			X

<sup>1</sup> Angalarri Valley: lower reaches of the Angalarri River (non-tidal), Ikymbon River

<sup>2</sup> Angalarri River: upper reach

<sup>3</sup> Koolendong Valley: Lobby Creek, Lalngang Creek, Salt Creek

<sup>4</sup> Yambarran Plateau: Little Fitzmaurice River, unnamed stream (14°59'46"S, 130°27'31"E), unnamed stream (15°13'03"S, 130°25'08"E)

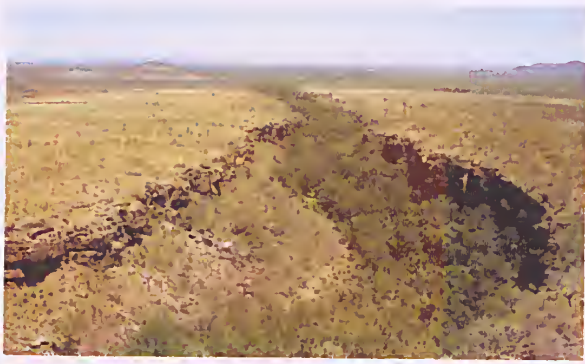


Fig. 3. Aerial view indicating the distinctive features of the upper Angalarri River (L. Corbett).



Fig. 4. The main survey pool where all Angalarri grunters were captured and stream characteristics measured (L. Corbett).

*Scortum neili* was common in the surveyed pool and, given the presence of other similar pools, the species is likely to be common throughout the upper reaches of the Angalarri River (Fig. 3). The reason for its apparent confinement in the upper reaches of the Angalarri River is most likely related to the distinctive habitat characteristics there. The large, permanent, deep pools with rocky substrate, continuous canopy (Fig. 4), submerged and exposed fringing tree roots apparently provides suitable microhabitat, food, shelter and possible breeding sites for the species. Despite several ground and aerial surveys, these stream features were rarely recorded elsewhere on BFTA, where deep pools had little overhanging, or submerged, vegetation and stretches of streams with good fringing vegetation were shallow or lacked large rocks on the substrate. However, additional intensive sampling of fishes throughout the Angalarri valley will be required to confirm the distribution of the *Scortum neili* in BFTA.

#### ACKNOWLEDGMENT

This survey was commissioned by the Department of Defence to determine the current status of the Angalarri grunter at its original collection site and to further describe the major ecological characteristics of its habitat.

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Accepted 14 November 2002



## A new genus of small coral-reef goby (Teleostei: Gobiidae) from the Indo-west Pacific, with discussion of its relationships

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### ABSTRACT

A new genus and species, *Minysicya caudimaculata*, is created for a small coral reef gobiine known so far from the Yaeyama Islands, Ryukyu Archipelago, Japan; Scott Reef off northern Western Australia; Lizard Island, Queensland; and the Tuamotu Islands, French Polynesia. Phylogenetic analysis shows that *Minysicya* n. gen. forms a monophyletic group with five other genera including *Bryaninops* and *Pleurosicya* (commensal on various invertebrates and plants), but has fewer of the specialisations exhibited by the other genera.

KEYWORDS: Indo-Pacific, Gobiidae, Gobiinae, *Minysicya caudimaculata* new genus new species, *Bryaninops*, *Pleurosicya*, commensal.

### INTRODUCTION

In 1984, Barry Russell of the Museum and Art Gallery of the Northern Territory, Darwin, collected five gobiid fish specimens that resembled the commensal goby genus *Bryaninops* Smith, from Scott Reef, off north-western Australia. From their characters of separate interorbital canals on the head, a very reduced fold anteriorly on the frænum, reduction or absence of pelvic fin lobes, very fine teeth with no canines present, and lower pectoral rays unbranched (but unthickened), the specimens appeared to be an unspecialised form of *Bryaninops*, with body morphology resembling *Bryaninops natans* Larson, 1985. However, the new specimens had no posterior oculoscapular canal over the preoperculum, unlike *Bryaninops*. During a visit to Okinawa in 1985, I found a single specimen (from Iriomote-jima) in the University of the Ryukyus' fish collection. Dr T. Yoshino kindly allowed me to borrow the specimen to compare with the Western Australian material. Additional specimens from Lizard Island, Queensland, Ishigaki-jima, Japan, and the Tuamotus, French Polynesia, were eventually recognised as belonging to this species.

One specimen was cleared and counter-stained, for osteological comparison with other gobiines. It was found to belong to the large coral reef Priolepis Group, a phenetic grouping which includes the majority of Indo-Pacific coral reef gobiines (Birdsong *et al.* 1988), including the "seawhip-gobies" (*Bryaninops*) and other coral and octocoral commensals (e.g. *Pleurosicya* and *Lobulogobius*). The genus and its only known species are here described as new.

### METHODS AND MATERIAL

Counts and measurements follow the methods used by Larson (1985). Specimens are deposited in the Australian Museum, Sydney (AMS); Biological Laboratory, The Imperial Household, Tokyo (BLIH); Museum and Art Gallery of the Northern Territory, Darwin (NTM); and the University of the Ryukyus, Naha (URM).

I suspected that the small commensal gobies probably form a monophyletic group within the diverse Priolepis Group of Birdsong *et al.* (1988) (and see Larson 1990), so the new genus was compared with *Bryaninops*, *Pleurosicya*, *Phyllogobius*, *Luposicya* and *Lobulogobius*. These five genera are all commensal on corals, gorgonians and other invertebrates and exhibit several specialisations (Larson 1990). For the phylogenetic analyses, characters were polarised against other gobiines as indicated below. *Acentrogobius* (*caninus* species-group), *Bathygobius* and *Glossogobius* were used as outgroups, and all possess the character states assigned to the composite outgroup in the matrix in Table 2. These genera are generally accepted as being less specialized than many of the other gobiines which include the "coral reef" commensal goby genera (Gill *et al.* 1992; Birdsong *et al.* 1988). Analyses were made using PAUP\* 4 beta10 (Swofford 2002), with characters unordered and unweighted.

Cleared and stained comparative material examined included: *Bryaninops amplus* (one paratype, NTM S.11082-001; one specimen, NTM S.13026-001), *B. isis* (one specimen, NTM S.13030-001), *B. yongei* (one specimen, NTM S.13028-001; one specimen, NTM

S.13029-001; one specimen, NTM S.13025-001), *Lobulogobius omanensis* (one specimen, NTM unregistered), *Luposicya lupus* (one specimen, NTM S.12717-001), *Phyllogobius platycephalops* (one specimen, NTM S.13027-001), *Pleurosicya amandalei* (three specimens, NTM unregistered), *P. coerulea* (one specimen, NTM S.13032-001), *P. fringilla* (one specimen, NTM S.13031-001), *P. mossambica* (one specimen, NTM S.12642-001), and *P. prognatha* (one specimen, NTM S.21316-001).

## SYSTEMATICS

### Family Gobiidae Subfamily Gobiinae *Minysicya* new genus

**Type species.** *Minysicya caudimaculata* new species, by original designation.

**Diagnosis.** Small, slender goby with first dorsal VI; second dorsal and anal rays I,8; pectoral rays all unbranched, usually with 14 rays, none thickened; longitudinal scales 22-24; TRB 6-7; scales on body ctenoid, extending forward to just above pectoral base, not extending onto head; pelvic fins small, fused, forming narrow cup, with very narrow anteriorly-facing fold on fraenum often present, pelvic spines with no or almost no fleshy lobe development; sensory papillae on head reduced; oculoscapular canals on head separate, with two anterior and two posterior interorbital pores, no posterior oculoscapular canal, no nasal pores, three preopercular pores; no canine teeth present; upper jaw protrusible, opening downward; body translucent with six red internal bars and small black spots at base of caudal fin; known from coral reefs and associated algal and seagrass beds.

**Osteology.** Based on two specimens, 8.5-13 mm SL. Branchiostegal rays 5; no dorsal post-cleithrum; no mesopterygoid; metapterygoid reduced, does not reach quadrate; short process reaches from preoperculum toward posteroventral portion of symplectic (the two bones are close due to enlarged orbit); pterygoid broad, especially ventrally; palatine very slender, extending about half the length of pterygoid; premaxilla straight, with tall ascending process (equal in height to length of premaxilla), distinct triangular articular process present; maxilla narrow but stout, posterior tip rounded; dentary short and stout, curving steeply upward at about mid-point of bone, teeth present along whole length of dentary; articular long, broadening posteriorly; frontals broadest posteriorly, anteriorly form upswept ridge over orbit dorsally; supraoccipital without median crest, narrow anteromedian projection present part-way over frontals; sphenotic narrow, just touching lateral wing of supraoccipital; basihyal long, narrow, broadening toward tip; scapula entirely cartilaginous; anteroventrally-

directed short slender ventral processes of pelvic bones diverging at tips and forming narrow Y; pelvic fin spines straight; vertebrae 10+16, including urostyle; haemal arches of first few caudal vertebrae expanded, amount of expansion decreasing posteriorly; short pleural rib present on first caudal vertebra only; last abdominal vertebra with long pleural ribs, which nearly meet ventrally; caudal skeleton with hypurals 1-2 fused to urostyle (in larger specimen); single epural; neural spine on last vertebra very low and rhomboid; hypural 5 rod-like; parhypural free, with low ventral flange.

**Etymology.** From the Greek *minys* (small), referring to the very small adult size of this species (largest specimen a 15 mm SL mature female) and *sikya* (an old Greek word for a cupping-glass), referring to the distinctive, cup-shaped pelvic fins of this fish's closest relatives, and echoing the names of two of these, *Pleurosicya* and *Luposicya*. Gender is feminine.

### *Minysicya caudimaculata* new species

(Figs 1-6; Table 1)

**Type Material.** HOLOTYPE - NTM S. 11383-027, 13 mm SL male, North Reef, Scott Reef, Western Australia, 20 m depth, coll. B.C. Russell, 11 September 1984. PARATYPES - out of NTM S. 11383-033, 3(13-13.5), one cleared and double-stained, same data as holotype; NTM S.11373-049, 1(13), Scott Reef, 20-25 m depth, coll. B.C. Russell, 8 September 1984; AMS I.25121-009, 8(7-12), 2.8 km E of Crystal Beach, Lizard Island, 36-38 m depth, epibenthic plankton sled, coll. J.M. Leis, 31 January 1982; URM P.4686, 1(14), Amitori Bay, Iriomote-jima, Ryukyu Islands, coll. T. Yoshino and K. Shimada, 9 September 1982; BLIH 1992269, 5(13.3-15), *Zostera* seagrass bed, Kabira Bay, Ishigaki, Ishigaki-jima, Okinawa, 3-4 m depth, coll. S. Hosoya, A. Iwata, Y. Ikeda, 25 November 1992; BLIH 1992241, 10(14-14.9), same data as preceding; AMS I.34514-011, 4(8-10.5), 600 m NE of house, Taiaro Atoll lagoon, Tuamotu Islands, French Polynesia, 15-18 m depth, rotenone, coll. P. Doherty, J. Leis and T. Trnski, 17 February 1994; AMS I.34514-014, 1(8.5), cleared and double-stained, 600 m NE of house, Taiaro Atoll lagoon, Tuamotu Islands, French Polynesia, 15-18 m depth, rotenone, coll. P. Doherty, J. Leis and T.



**Fig. 1.** Holotype of *Minysicya caudimaculata* n. gen. n. sp., NTM S. 11383-027, 13 mm SL male, Scott Reef, Western Australia. Photograph by Rex Williams.



**Table 1.** Meristics and measurements (in mm) of *Minysicya caudimaculata* n. gen. n. sp.

	Mean	Max.	Min.	Mode
First dorsal	6.0	6.0	5.0	6.0
Second dorsal	7.8	8.0	7.0	8.0
Anal	8.0	9.0	7.0	8.0
Pectoral	13.7	15.0	12.0	14.0
Lateral scales	23.0	24.0	21.0	23.0
TRB	6.2	7.0	5.0	6.0
SL	12.6	15.0	9.0	14.0
Head length	3.8	4.5	2.9	4.1
Head depth	2.1	2.5	1.7	2.0
Head width	1.8	2.0	1.5	1.9
Body depth	2.4	3.0	1.8	2.2
Caud. ped. leng.	3.4	4.3	2.4	3.3
Caud. ped. depth	1.2	1.5	0.9	1.4
Snout length	1.0	1.3	0.6	1.0
Eye width	1.3	1.5	1.0	1.4
Jaw length	1.2	1.5	0.8	1.3
Interorbital	0.6	0.8	0.5	0.6
Pectoral length	2.6	3.0	2.1	2.5
Pelvic length	1.9	2.3	1.5	2.0
Caudal length	3.0	3.3	2.4	3.3

Trnski, 17 February 1994; AMS I.34515-007, 5(9-12), 600 m E of house, Taiaro Atoll lagoon, Tuamotu Islands, French Polynesia, 24 m depth, rotenone, coll. P. Doherty, J. Leis and T. Trnski, 18 February 1994; AMS I.34866-003, 1(9.5), southern corner of lagoon, Taiaro Atoll, Tuamotu Islands, French Polynesia, 4-8 m depth, rotenone, coll. P. Doherty, J. Leis and T. Trnski, 17 February 1994.

**Additional material.** AMS I.34510-036, 1(8), off collapsed wharf, Taiaro Atoll, Tuamotu Islands, French Polynesia, 0-2 m, coll. Taiaro party, 14 February 1994 [not in good condition].

**Description.** Based on 32 specimens, 8.5-15 mm SL. An asterisk indicates counts of the holotype (Fig. 1). Osteological information from two cleared and stained specimens.

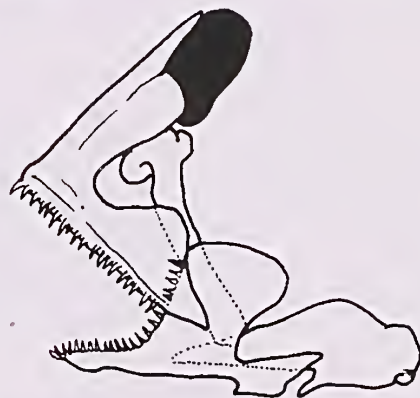
First dorsal VI\* (V in one); second dorsal 1,7-8\*, modally 1,8; anal 1,7-8\*, modally 1,8, pectoral rays 12-15 (modally 14, 13 in holotype), segmented caudal rays 17\*; caudal ray pattern 9/8; branched caudal rays 6/5; unsegmented (procurent) caudal rays 4/3; longitudinal scale count 21-24 (mean 23\*); TRB 5-7, usually 6\* (Table 1). Pterygiophore formula 3-22110. Vertebrae 10+16. Pectoral fin rays all unbranched. Neural spines of first few vertebrae slender and pointed. One epural. Two anal pterygiophores before haemal spine of first caudal vertebra. First four caudal vertebrae with widely expanded haemal arches; first caudal vertebra with pleural ribs.

Head and body slender, compressed, head length 3.1-3.5 (mean 3.3) in SL. Head depth at posterior preopercular margin 1.7-2.0 (mean 1.8) in HL. Head narrow, width at posterior preopercular margin 1.9-2.5

(mean 2.2) in HL. Mouth short, terminal, lower jaw tip usually anteriormost; jaws just reaching to below anterior margin of eye. Lips thin, smooth. Upper jaw 2.7-3.6 (mean 3.1) in HL; fully extended jaws protruding forward and downward. Eye large, lateral, top forming part of dorsal profile, 2.6-3.2 (mean 2.9) in HL. Snout pointed, often with convexity before eye due to long ascending process of premaxilla, 3.3-4.9 (mean 4.1) in HL. Interorbital relatively flat, moderate in width, 4.9-8.8 (mean 6.1) in HL. Body depth at anal origin 4.5-6.3 (mean 5.3) in SL. Caudal peduncle long, slender, length 3.3-4.8 (mean 3.8) in SL. Caudal peduncle depth 9.3-12.5 in SL (mean 10.7).

No mental fracnum, lower lip free at sides, narrowly joined to chin anteriorly. Anterior nostril in slender thin tube placed just closer to upper lip than to eye; posterior nostril oval, without raised rim, placed close to anterodorsal edge of eye. Gill opening extending forward to under mid-opercle. Lower quarter (at most) of first gill arch bound to opercle by membrane. Gill rakers on outer face of first arch reduced to few short stubby rakers by angle of arch, rudiments present on lower limb; rakers on inner face of arches short and stubby, rakers on outer face of other arches short, stubby, with few tiny spines at tip. Tongue thin, tip usually blunt, slightly concave or slightly irregular.

Outer row teeth in upper jaw small, curved, sharp and evenly sized (no canines); one or two rows of very tiny short pointed teeth behind outer row across front of jaw only. Lower jaw with four to five rows of curved, sharp, evenly sized teeth across front, only one row of teeth along side of jaw, with largest teeth posteriormost. Lower jaw sexually dimorphic. In males, posterior portion of dentary steeply curved dorsally, so that rear teeth on dentary point almost anteriorly (Fig. 2). In females, posterior portion of dentary less curved dorsally and teeth along side of jaw smaller than in males or absent from curved portion of dentary altogether.



**Fig. 2.** Jaws of *Minysicya caudimaculata* n. gen. n. sp., showing curved dentary and small anteriorly-oriented teeth, ex NTM S.11383-027, 14 mm SL male. Cartilage shown in black.

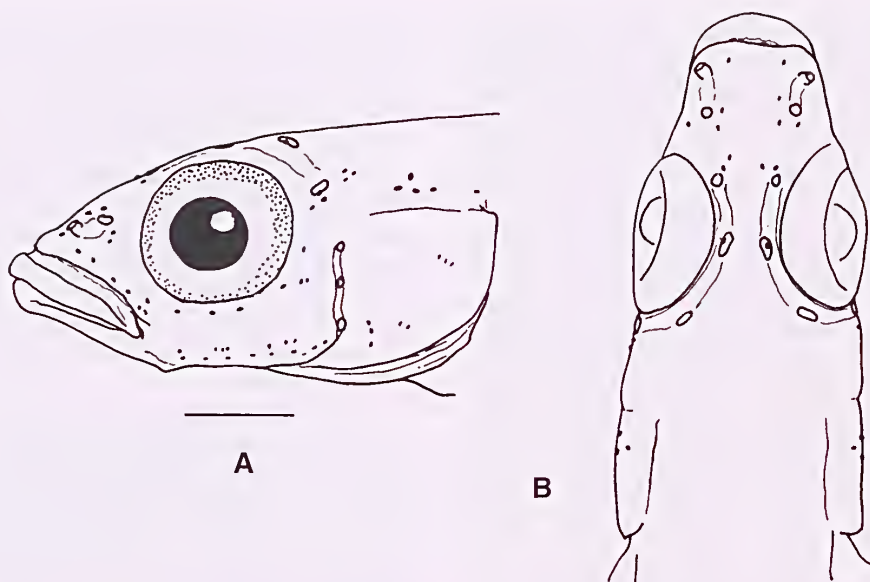


Fig. 3. *Minysicya caudimaculata* n. gen. n. sp., BLIH 1992269, 14.5 mm SL paratype female. A, lateral view of head, showing sensory papillae; B, dorsal view of head, showing oculoscapular canals and pores. Scale bar = 1 mm.

Head, nape, pectoral base, breast and belly naked. Ctenoid scales on side of body extend forward to just above pectoral base.

Head pore pattern reduced (Fig. 3). No nasal pores; paired anterior and posterior interorbital pores in separate interorbital canals, postorbital pore behind eye, infraorbital pore below postorbital, no posterior oculoscapular canal or pores; three preopercular pores present (rarely, preopercular canal open).

Sensory papillae pattern on head in reduced longitudinal pattern, as in Figure 3.

First dorsal fin approximately triangular, rounded to slightly pointed in outline, origin directly over pelvic fin origin. First dorsal fin spine slightly shorter than next two; fin not reaching first element of second dorsal fin when depressed. Second dorsal fin short, anterior rays longest, more than twice height of posteriormost ray, giving fin a triangular appearance. Anal fin similar in shape, but third or fourth rays longest. Pectoral fin pointed, central rays longest, all rays unbranched, tips of rays not thickened, 4.2–5.8 (mean 4.9) in SL. Pelvic fins (Fig. 4) fused, forming oval cup, reaching to anus, 5.8–8.8 (mean 6.9) in SL; first to fourth rays branched 2–5 times at tips, which are free of membrane, fifth ray narrower than others and unbranched or only branched once; skin around tips of pelvic spines thickened in some specimens, tips of rays usually slightly thickened; edge of fraenum slightly thickened and rolled forward in most specimens. Caudal fin slightly rounded to truncate, 3.6–5.0 (mean 4.3) in SL.

Male genital papilla elongate, slender, flattened distally, narrowing toward tip, which is expanded and fimbriate. Female genital papilla short, bulbous, with

two finger-like lobes on either side of opening (resembling cow's udder).

**Coloration of preserved material.** Head and body pale whitish to pale brown (depending upon preservation), with most conspicuous markings being three dark brown spots around the caudal fin base (Fig. 5). Head unpigmented but for variable dusting of melanophores behind eye (some pigment internal, over brain, visible through body tissues), few melanophores below anterior nostril or on upper lip. Iris encircled with dark brown.



Fig. 4. Pelvic fins of *Minysicya caudimaculata* n. gen. n. sp., showing reduced fold on frenum, BLIH 1992241, 14 mm SL male. Scale bar = 0.5 mm.



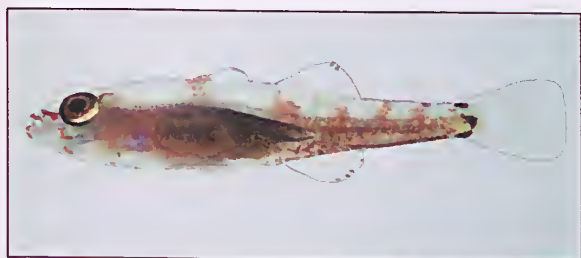


Fig. 5. *Minysicya caudimaculata* n. gen. n. sp., recently dead specimen (URM P.4686) from Amitori Bay, Iriomote-jima, Japan. From colour slide by T. Yoshino. Fin outlines reconstructed.



Fig. 6. Living *Minysicya caudimaculata* n. gen. n. sp. over seagrass bed, 3 m in depth, at Kabira Bay, Ishigaki-jima, Okinawa. Photograph by Seiichi Hosoya.

Peritoneum evenly speckled with brown dorsally and laterally, usually unpigmented ventrally, pigment showing through body wall. Breast with one to several melanophores, some internal and directly dorsal to melanophores on skin; pigment may form narrow streak along mid-ventral line of breast and isthmus. Anus and genital papilla usually unpigmented. Fine brown speckling present along mid-ventral line of body, extending dorsally about a quarter-way up side of body, speckling usually forming indistinct streak running from anal fin origin to just before lowermost dark spot on caudal base; speckling may be diffuse or reduced to thin mid-ventral brown line only.

On middle of caudal fin base, a small, approximately triangular to diamond-shaped dense dark brown spot present, spot may extend out onto caudal rays; similar spots across dorsal and ventral precurrent rays. In some specimens, small dark specklings join all three spots together along hypural crease. Area on caudal peduncle immediately anterior to three dark spots almost always unpigmented.

First dorsal fin translucent, with tip or distal third of fin with diffuse blackish spot or dusky band, some specimens with few distinct melanophores on anterior fin membranes close to fin base. Second dorsal fin translucent, with scattered melanophores or diffuse dusky band distally, or fin unpigmented. Anal fin similar to second dorsal. Pectoral and pelvic fins

translucent to whitish, unpigmented. Caudal fin translucent, with even dusting of brown pigment, usually diffuse; some specimens with fin unpigmented.

**Coloration of fresh material.** A colour slide of the URM paratype from Iriomote-jima, taken shortly after death, shows that the caudal fin base and dorsal and anal fin spots are black, the pigment on the peritoneum and ventral streak along the caudal peduncle is brown; the head markings are bright red, and an internal red pigment pattern is present, consisting of a red line following the vertebral column and six short bars reaching dorsally from it. The iris is pale golden, outlined in black.

Colour images (by Seiichi Hosoya), sent to me just before going to press, are possibly of some of the paratypes in BLIH 1992269, as collection data are identical. The images show that the live fish are mostly transparent (Fig. 6) with indistinct reddish body bars, and peritoneum and vertebral column pale brown, whitish to yellowish-white dorsally. The skin covering the dorsal part of the eye is yellowish-white, crossed by two to three dark brown bars.

**Distribution and ecology.** This rarely-collected species is so far known from Amitori Bay, Iriomote-jima, Kabira Bay, Ishigaki-jima, Japan; Scott Reef, off Western Australia; Lizard Island, Queensland; and Taiaro Atoll, Tuamotu Islands, French Polynesia.

Its lack of pectoral and pelvic fin specialisation, the downward-opening jaws armed only with very tiny teeth, compressed body form and large eyes indicate that this species may live out over open sand or up in the water column. Unfortunately, there have been no underwater observations made on this fish while it was alive. Specimens were taken over *Halimeda* algal beds (Lizard Island), extensive *Caulerpa* beds (Scott Reef) and a *Zostera* seagrass bed (Ishigaki-jima). The Tuamotu specimens came from several lagoonal sites which included much algae, especially *Caulerpa*.

**Etymology.** The species name, *caudimaculata*, refers to the black spot at the base of the caudal fin.

## PHYLOGENETIC ANALYSIS

*Bryaninops*, *Lobulogobius*, *Luposicya*, *Minysicya*, *Pleurosicya* and *Phyllogobius* were analysed, with a composite outgroup of *Acentrogobius* (*caninus* species-group), *Bathygobius* and *Glossogobius*. Characters and character state polarity (0 = primitive; 1, 2 = derived) are listed below (also Table 2), with comments on the distribution of the characters within the Gobiidae.

### List of characters and polarity

1. Lower lip free at sides, fused to chin (0); lower lip fused at sides, free fold at chin (1).

Gobiines mostly do not have a free lip fold ventrally across the chin; usually the chin is smooth, although a



mental lobe or flap is present in some genera such as *Bathygobius* (Hoes 1986). It should be noted, however, that xenisthmids have the entire lower lip free (Springer 1983).

2. Ascending process of premaxillary pointed, distinct from articular process, although it may be low (0); ascending premaxillary process tip low, rounded, and fused with articular process, so that processes are indistinguishable (1).

The ascending and articular processes are usually separate or "differentiated" in gobiids, but are indistinguishable from each other in sicydiines (Harrison 1989; Parenti and Maciolek 1993). The derived condition, resembling that in sicydiines, is present in *Phyllogobius*.

3. Premaxilla without foramen (0); premaxilla with large foramen below ascending process (1).

This condition does not appear to have been observed in other gobiids, and may be an apomorphy for *Luposicya*.

4. Lower jaw teeth fixed, with no horizontally oriented teeth (0); lower jaw with one or more rows of horizontally-directed teeth on dorsal edge of dentary (1); lower jaw includes long comb-like row of teeth running along anterior face of dentary (2).

Both *Luposicya* and *Pleurosicya* have flexible horizontally-directed fine teeth, but their shape and arrangement on the dentary differs (Larson 1990). Most gobiids of the subfamily Gobiinae have fixed upright caniniform teeth. Several genera of sicydiine gobies are characterised by their fine horizontal teeth (Sakai and Nakamura 1979; Watson 1995).

5. Gill opening relatively restricted, extending from below pectoral base to under eye (0); gill opening wide, with gill membranes free from isthmus and each other (1).

Most gobiids have the gill membranes connected to the isthmus, although a few gobiine genera (such as *Lobulogobius*, *Phyllogobius* and some species of *Myrsina*) have the derived (free) condition.

6. Nape scaled (0); nape naked (1).

Predorsal scalation is rather plastic in gobiids, but generally the trend is for fewer scales or no scales in the more derived taxa. Many of the smaller coral reef forms have naked napes. The taxa generally considered to be "basal gobiids" (Gill *et al.* 1992; pers. observ.) and which were used as outgroups for the analysis (*Acentrogobius*, *Bathygobius*, *Glossogobius*), have scaled predorsals.

7. Interorbital canals united, anterior interorbital pore single (0); interorbital canals separate anteriorly, two anterior interorbital pores present; canals joined posteriorly, with medial posterior interorbital pore (1); interorbital canals completely separate, with paired anterior and posterior interorbital pores (2).

**Table 2.** Character states for the six commensal goby genera and the composite outgroup (*Acentrogobius-caninus* species group, *Bathygobius*, *Glossogobius*).

Genus	Characters															
	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6
Composite outgroup	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Bryaninops</i>	0	0	0	0	0	1	1	2	1	1	0	1	1	0	2	1
<i>Lobulogobius</i>	0	0	0	1	1	1	1	0	1	1	1	1	1	0	2	1
<i>Luposicya</i>	1	0	1	2	0	0	2	1	1	0	1	1	0	2	1	
<i>Minysicya</i>	0	0	0	0	1	2	1	0	1	0	0	1	1	1	1	
<i>Phyllogobius</i>	0	1	0	1	1	0	2	2	1	1	0	1	1	0	2	1
<i>Pleurosicya</i>	0	0	0	1	0	0	2	1	1	0	1	1	0	2	1	

Paired interorbital canals and anterior interorbital pores are plesiomorphic for gobiids, with united interorbital canals and a single anterior interorbital pore being a synapomorphy for the subfamily Gobiinae (Takagi 1989; Pezold 1993). *Luposicya* and *Pleurosicya* possess this typical gobiine state, while all but one species of *Bryaninops* (*B. natans* lacks the canal connecting the posterior interorbital pores; state 2) and *Lobulogobius* possess state 1, and *Minysicya* and *Phyllogobius* have state 2. Pezold (1993) discussed the reversal of pore pairs for this group of gobies.

8. Pectoral rays mostly branched, no thickening of rays (0); pectoral rays all unbranched, no thickening of rays (1); pectoral rays with lower two to nine rays unbranched, tips distinctly thickened (2).

Most gobiids have branched pectoral fin rays. Unbranched pectoral rays appear in several small coral reef gobiines such as *Sueviota* (Winterbottom and Hoes 1988) and *Trimmatom* (Winterbottom and Emery 1981). Thickening of the lower rays seems to be restricted to the small coral commensals *Bryaninops*, *Luposicya*, *Phyllogobius* and *Pleurosicya*. Other gobiines with relatively fleshy fins, such as *Gobiodon*, do not have the rays thickened, at the tips or otherwise.

9. Pelvic spines without fleshy surrounding lobes (0); pelvic spines surrounded by fleshy rounded flat lobes (1).

The fleshy lobes around the pelvic spines are found only in the coral commensals *Bryaninops*, *Lobulogobius*, *Luposicya*, *Phyllogobius* and *Pleurosicya*. The specialised coral commensals *Gobiodon* and *Paragobiodon* have thick fleshy pelvic disks, but the pelvic spine is not surrounded by a lobe. Superficially similar pads are found on the tip of the pelvic spine in sicydiines (Hocse 1984; Parenti and Maciolek 1993).

The pelvic fins in *Bryaninops* can actually be used to grip narrow branches of host antipatharians and gorgonians (Fig. 7), with the fleshy pelvic-fin spines curving around the branch.

10. First gill arch free of opercle (0); first gill arch partly bound to opercle by membrane (1).





Fig. 7. *Bryaninops tigris*, gripping tip of antipatharian (black coral) branch at Mabul, Malaysia. The fleshy pelvic-fin spines are curved around the branch, and the cup-shaped fins are folded accordingly. Photograph by Rudie Kuiter.

The derived condition appears occasionally among several gobiids, with the gobiine *Heteroleotris* showing the most extreme form (first gill slit completely closed by membrane). All six of the small coral commensal genera have the lowermost part of the first gill arch variably bound by membrane to the inner face of the opercle (*Lobulogobius* with the least amount, less than one quarter bound; *Phyllogobius* has at least half of the arch bound by membrane). *Minysicya* has the lowermost quarter of the first arch (or less) bound by membrane.

11. Preopercular edge smooth, without bony processes (0); preopercular edge with bony flange or several blunt bony teeth (1).

Few gobiines have bony teeth or flanges on the posterior preopercular margin, most notably *Asterropteryx* and the *Oploponus* species-group. *Lobulogobius* has this character state.

12. Pelvic rays not flattened and thickened, branching 1–2 times (0); pelvic rays thick, flattened, branching 3–6 times (1).

Flattening of pelvic rays occurs in the subfamily Sicydiinae and in the gobiionelline *Awaous* (Parenti and Maciolek 1993), but rarely in the Gobiinae.

13. Pelvic fraenum smooth, flat, not rolled or folded forward (0); pelvic fraenum smooth or fleshy, rolled or folded forward to form anteriorly-facing pocket (1).

In the Gobiinae, this character may be restricted to *Bryaninops* and its relatives. Some specimens of *B. diannae* (Larson 1987) have a greatly reduced forward fold on the fraenum, approaching that seen in *Minysicya*.

14. Oculoscaphular canal above opercle present (0); oculoscaphular canal above opercle absent (1).

Many gobiids have an oculoscaphular canal and terminal pore over the preopercle and opercle, but this canal is reduced in some coral reef genera such as *Bryaninops* and its relatives, and several species-groups within *Eviota* (Lachner and Karnella 1980; Pezold 1993). *Bryaninops*, *Lobulogobius*, *Luposicya*, *Phyllogobius* and *Pleurosicya* all have a short oculoscaphular canal extending over the preopercle only; and in *B. nexu*s the canal is broken just posterior to the eye (Larson 1987). Some specimens of *B. natans* lack this canal also. The oculoscaphular canal is always absent in *Minysicya*.

15. First haemal arch straight or obliquely-angled, not expanded laterally (0); first haemal arch expanded laterally (1); first haemal arch bent posteriorly (2).

In *Bryaninops*, *Pleurosicya*, *Phyllogobius*, *Luposicya* and *Lobulogobius*, the first haemal arch has a distinct back-curved shape. The expanded haemal arches resemble those reported by Winterbottom (1984) for *Trimma taylori* and *T. griffithsi*. This does not necessarily imply that the two groups are related. As Winterbottom states, most *Trimma* species do not have these arches expanded. The gobiionelline genus *Stigmatogobius* also has a similar form of haemal arch (Larson 2001). *Minysicya*, however, has the haemal arches of the first few caudal vertebrae expanded laterally, with the amount of expansion decreasing posteriorly, but the haemal arches are not bent posteriorly.

16. Papilla pattern with at least three longitudinal rows crossing cheek (0); papilla pattern greatly reduced, longitudinal, only one complete row crossing cheek (1).

It has been demonstrated that the least specialised gobiids have four to five rows of sensory papillae crossing the cheek (Hoese and Gill 1993), and the more derived taxa have reduced papillae rows (for example, *Eviota*, *Fusigobius*, *Priolepis* and *Trimma* (see Akihito *et al.* 1988).

**Results of analyses.** The PAUP\* alltrees option (exhaustive search, characters unordered and unweighted), with five characters (autapomorphies) excluded, produced 25 equally parsimonious trees (CI = 0.67, RI = 0.33) of 21 steps. The trees all showed *Minysicya* placed below the other commensal taxa, but a strict consensus tree of these 25 (Fig. 8) gave no information as to relationships between the taxa, other than that *Minysicya* was less derived than the five others.



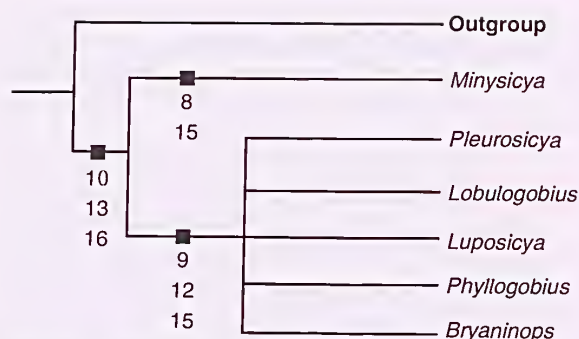


Fig. 8. Result of PAUP analysis, exhaustive search; strict consensus of 25 trees.

All six of these taxa share three synapomorphies (derived states of characters 10, 13 and 16): the first gill arch partly bound to inner face of the opercle (10), pelvic fin fraenum rolled forward to form a pocket (13) and a greatly reduced sensory papillae pattern (16). Five taxa, other than *Minysicya*, share the derived condition for characters 9 (pelvic spines with fleshy round lobes); 12 (pelvic rays broad, flattened and many-branched) and 15 (posteriorly-bent first haemal arch). *Minysicya* is supported by two characters: 8 (pectoral rays unbranched but not thickened at tips; state 1) and 15 (first haemal arch expansion; state 1).

**Relationships.** Given the limitations of the available data, it is not possible to resolve the relationships within this group any further, other than saying that this small group of commensal gobies is monophyletic. However, I speculate that *Minysicya* may be more closely related to *Bryaninops*, as it shares some features with some species of this genus. *Minysicya* lacks the posterior portion of the oculoscapular canal and pore over the preoperculum, and this condition is sometimes present in *B. natans*, which also lacks the canal connecting the posterior interorbital pores. *Bryaninops natans* also hovers above its associates (corals) instead of clinging to them as do most *Bryaninops* species; *Minysicya* hovers above sand, seagrass and macroalgae beds (Fig. 6). The jaw shape and teeth in *Minysicya* resemble those of *Bryaninops ridens* and *B. isis*, in that these species all have small even teeth and no canines on the side of the lower jaw. *Minysicya* has a much-reduced fold on the fraenum and the lobes on the pelvic spines are not developed (just thickened tips to spines present). The greatly reduced forward fold on the fraenum in *Minysicya* resembles that observed in a few specimens of the sponge-commensal *B. diannae* (Larson 1987).

#### ACKNOWLEDGMENTS

My many thanks to Dr T. Yoshino, for allowing me a long-term loan of the URM specimen and his colour slide of its fresh colouring; to Jeff Leis (AMS) for

sending me the Tuamotu material; and to Akihisa Iwata (formerly of BLIH) and Y. Ikeda (BLIH) for sending me the Ishigaki specimens just when I thought the manuscript was finished. Thanks to Rudie Kuiter for the use of the *Bryaninops* image. And many thanks to Seiichi Hosoya for sending photographs of live *Minysicya* at very short notice.

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Accepted 22 October 2002





## Two new records of *Parascolopsis* (Pisces: Nemipteridae) from the west coast of India, with a redescription of *Parascolopsis boesemani* (Rao and Rao)

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### ABSTRACT

The occurrence of the dwarf monocle breams *Parascolopsis eriomma* (Jordan and Richardson) and *P. boesemani* (Rao and Rao) (Pisces: Nemipteridae) from the west coast of India is reported for the first time based on specimens collected from off Goa. *Parascolopsis boesemani* is redescribed and compared with other congeners. A key to the western Indian Ocean species of *Parascolopsis* is provided.

KEYWORDS: Pisces, Nemipteridae, *Parascolopsis*, new records, west coast of India, key, western Indian Ocean species.

### INTRODUCTION

Of the 11 species of dwarf monocle breams, genus *Parascolopsis* (Pisces: Nemipteridae), recorded from the Indian and Pacific Oceans, seven are known to occur along the Indian subcontinent, including Sri Lanka: *P. inermis* (Schlegel), *P. townsendi* Boulenger, *P. eriomma* (Jordan and Richardson), *P. aspinosa* (Rao and Rao), *P. boesemani* (Rao and Rao), *P. baranesi* Russell and Golani and *P. capitinis* Russell (Russell 1990; Russell and Golani 1993; Russell 1996). Among the Indian species, only *P. aspinosa* was previously known to have a wide distribution, and is found along both coasts (Russell 1990).

During cruises along the west coast of India by the Fishery Survey of India vessel MFV *Matsya Vishwa* in August and September 1998, one specimen of *Parascolopsis eriomma* and two specimens of a red-spot *Parascolopsis*, later confirmed to be *P. boesemani*, were collected. *Parascolopsis boesemani* was initially described from a single and, until now, the only known specimen, collected from Waltair on the east coast of India.

The recently collected specimens represent the first confirmed record of *Parascolopsis eriomma*, and the first record of *P. boesemani*, from the west coast of India. Based on the additional specimens, *P. boesemani* is redescribed, and a key to the western Indian Ocean species of *Parascolopsis* is provided.

### METHODS

The specimens were deep-frozen before they were brought to shore for examination. The colour and

pigmentation was observed in fresh condition as well as after thawing. All measurements were taken with vernier callipers to the nearest 0.1 mm. Length measurements are standard length (SL). Terminology, measurements and counts are the same as those used by Russell and Golani (1993). The specimens referred to in this paper are deposited in the Museum and Art Gallery of the Northern Territory, Darwin, Australia (NTM), and the National Museum of Natural History, Leiden, Netherlands (RMNH).

### SYSTEMATICS

*Parascolopsis eriomma* (Jordan and Richardson, 1909)  
(Fig. 1)

*Scolopsis eriomma* Jordan and Richardson, 1909: 108, pl. 80 (Formosa [now Taiwan]; Ceylon [now Sri Lanka]).

**Material examined.** NTM S.15354–001, 186 mm SL (spent female), Goa, central west coast of India (15° 54'N, 72° 54'E), MFV *Matsya Vishwa*, demersal trawl, 16 September 1998, depth 145 m.

**Description.** Dorsal rays X,9; anal rays III,7; pectoral rays ii,14; principle caudal rays 18; lateral line scales 36, transverse scale rows 3/10½; gill rakers 17. Body moderately deep, 2.8 in SL, head 3.3 in SL, head length less than body depth, body depth 0.8 in head; snout short, bluntly rounded, 5.7 in head; eye 2.7 in head; diameter of the eye greater than snout length, eye 0.5 in snout; interorbital width equal to eye diameter; suborbital narrow, least depth, 2.5 in eye diameter. Dorsal fin length 1.9 in SL, fifth dorsal ray longest, about equal to length of longest spine (fourth



Fig. 1. *Parascolopsis eriomma*, NTM S.15354-001, 186 mm SL, off Goa, India.

dorsal spine). Anal fin length 5.5 in SL. first anal spine 1.8 in second, second 1.5 in third. Pectoral fins moderately long, reaching to level of vent, their length 1.1 in head. Pelvic fins moderately long, reaching to level of vent, their length 1.4 in head length. Length of pectoral fin 1.3 in pelvic fin.

Mouth rather small, maxillary reaching beyond anterior margin of the pupil (Fig. 1). Jaw teeth villiform. Scales on top of head extending forward to mid-pupil; snout naked; suborbital naked, with small spine at upper corner and fine denticulations on posterior margin. Premaxilla naked. Preopercle with five transverse scale rows and broad naked flange; posterior margin of preopercle finely denticulate. Dorsal fin emarginate; caudal fin slightly forked. Gill rakers spatulate, compressed, with nine spines along distal margin.

**Colour.** Body rosy with orange tinge, pale below lateral line (Fig. 1). Golden yellow stripe clearly marked at the mid-posterior margin of pupil to the margin of the eye, but becoming diffused on the preopercle and opercle in the form of an indistinct pale yellowish band, which extends to the beginning of caudal peduncle. Preopercle and opercle with yellow sheen. Dorsal fin pink, its spinous margin reddish. Caudal fin rosy pink, its lower lobe pale yellow. Anal and pelvic fins milky white, suffused with pale yellow. Pectoral fins translucent yellow.

**Remarks.** Although Fisher and Bianchi (1984) indicated that the distribution of *Parascolopsis eriomma* includes the west coast of India, our specimen represents the first confirmed record from western Indian waters. The species was previously recorded from Vishakhapatnam, eastern India (Russell and Golani 1993) and Sri Lanka (Russell 1996).

***Parascolopsis boesemani* (Rao and Rao, 1981)**

(Fig. 2, Table 1)

*Scolopsis boesemani* Rao and Rao, 1981: 139, figs 2, 4 (Waltair, India).

**Material examined.** NTM S.15355-001, 2 specimens: 82.5–108 mm SL (both females) captured

off Goa, India (14° 58' N, 73° 14' E), demersal trawl, MFV *Matsya Vishwa*, 28 October 1998, depth 110–115 m.

**Additional material examined.** HOLOTYPE: RMNH 28191, 90.7 mm SL, Waltair, India.

**Description.** Dorsal rays X,9; anal rays III,7; pectoral rays ii,14; principle caudal rays 18; lateral line scales 39–41, transverse scale rows 3/14; gill rakers 9. Body moderately deep, 2.5–2.7 in SL. Head 2.4–2.5 in SL; head length greater than or equal to body depth, length of head 0.9–1.0 in body depth. Snout short, rounded, 5.2–5.4 in head length; eye 3.2–3.6 in head length; snout length less than eye diameter, 1.5 to 1.6 in eye; interorbital width 1.1–1.3 times in diameter of eye; suborbital shallow, least depth 4.8 times in diameter of eye. Dorsal fin length 2.0–2.3 in SL; fourth or fifth dorsal spine usually longest, and 1.9–2.3 times length of first dorsal spine; second through fifth dorsal rays longest, 1.1–1.2 times length of longest dorsal spine. Anal fin length 7.2–6.6 in SL; length of first anal spine 1.6–1.9 in second; length of second anal spine equal in length to third. Pectoral fins long, reaching to or beyond level of vent, 1.4 times in head length. Pelvic fins moderately long, not reaching to the level of vent, 1.7–2.0 times in head length.

Mouth of moderate size, maxillary reaching to about level to a vertical through anterior margin of pupil (Fig. 2). Jaw teeth villiform, in narrow bands tapering posteriorly in both jaws. Upper jaw with a series of small curved canines decreasing in size posteriorly on either side, and forming a narrow band of teeth. Lower jaw also with a band of teeth on either side, but these slightly smaller compared to teeth in upper jaw. Scales on top of head extending forward between eyes to above about posterior margin of pupil. Preopercle with five transverse rows of scales, its lower margin naked.

**Colour.** Body rosy pink, with three vertical, dark orange bands: first in front of first dorsal spine; second from the orange blotch of dorsal fin to anal fin, merging with colour of anal fin membrane; third from end of dorsal fin to end of anal fin, and extending over half of caudal peduncle (Fig. 2). Two greenish, golden yellow



Fig. 2. *Parascolopsis boesemani*, NTM S.15355-001, 82.5 mm SL, off Goa, India.



**Table 1.** Comparison of characters of the species of red-spot *Parascolopsis* and the specimens of *P. boesemani* collected from off Goa, western India.

	<i>P. rufomaculatus</i>	<i>P. baranesi</i>	<i>P. boesemani</i> holotype	<i>P. boesemani</i> specimens collected off Goa
SL (mm)	83.4-153.0	77.3-111.6	90.7	82.5-108.0
No. lateral-line scales	35-37	39	37	39-41
Pectoral fins	Moderately long, reaching to or just short of vent	Moderately long, reaching to or just short of vent	Long, reaching beyond vent	Long, reaching beyond vent
Pelvic fins	Short, not reaching vent	Short, not reaching vent	Long, reaching beyond vent	Short, not reaching vent
Scales on top of head	Reaching forward to middle of eye	Reaching forward to anterior nostril	Reaching forward posterior nostril	Reaching forward to posterior nostril
Body colour	Body pinkish, pearly white below	Body pale pink, silvery below mid-lateral line	Rosy yellow	Rosy pink
Vertical bands on body	No vertical bands	Traces of three vertical bands on upper half of body	Three pale rosy saddles on body and one on caudal fin peduncle	Three vertical, dark orange bands: first in front of dorsal fin, second from middle of dorsal fin, third on caudal peduncle

stripes running length of body: upper stripe extending from upper margin of eye to caudal fin base; lower stripe extending from base of pectoral fin to base of caudal fin. Pelvic fins pinkish orange anteriorly and milky white posteriorly. Pectoral fins golden yellow at base and pinkish along margin. Spinous part of dorsal fin membrane whitish at notch with blood red spot bordered with golden yellow pigmentation between sixth and tenth spine. Small pale red inconspicuous spot present between first and third soft ray; soft part of dorsal fin edged pink. Anal fin milky white, with pale red blotch on spinous portion, this colour extending to second anal fin ray. Caudal fin pale pink with red blotch centrally, paling towards lower portion.

**Colour (in alcohol).** Body pale brown below lateral line and darker above; three dark brown stripes running parallel to axis of body below lateral line, paler ventrally. Three vertical bands across body visible as blotches on dorsalmost stripe, the darkest of the three stripes.

**Remarks.** The specimens of *Parascolopsis boesemani* collected from the west coast of India differ slightly from the original description given by Rao and Rao (1981) in having shorter pelvic fins, not reaching the level of the vent (versus longer pelvic fin in the holotype of *P. boesemani*), and in having three stripes on the body (versus four in the holotype). In all other characters, our specimens closely resemble the holotype of *P. boesemani* and therefore are regarded as the same species.

*Parascolopsis boesemani* is one of three closely related species of *Parascolopsis*, all characterised by having a distinctive red spot in the middle of the dorsal fin: *P. baranesi*, *P. boesemani* and *P. rufomaculatus*

Russell, 1986. *Parascolopsis boesemani* differs from *P. rufomaculatus* notably in having the scales on top of the head reaching forward to the posterior nostrils (versus reaching forward only to middle of eye in *P. rufomaculatus*). *Parascolopsis boesemani* is closest to *P. baranesi*, but has longer pectorals (reaching beyond the vent), and head scales reaching forward to level of posterior nostril (versus head scales reaching to level of anterior nostril in *P. baranesi*), and has a darker body, with the stripes appearing clearly on its lower half.

A comparison of characteristics of our two specimens with the holotype of *P. boesemani* and the other species of red-spot *Parascolopsis* is given in Table 1.

#### Key to western Indian Ocean species of *Parascolopsis*

- 1a. Gill rakers on first arch 8-13 ..... 2
- 1b. Gill rakers on first arch 17-19 (Indo-W. Pacific) ..... *P. erionuna*
- 2a. Pectoral fins reaching to, or just short of, vent; red blotch on dorsal fin between seventh and tenth dorsal spines (lost in preservative) (Gulf of Aqaba) ..... *P. baranesi*
- 2b. Pectoral fins reaching beyond vent; dorsal fin with or without black blotch ..... 3
- 3a. Scales on top of head not reaching to above anterior margin of eye; suborbital and premaxilla naked; margin of suborbital usually smooth; preopercle with 4-6 transverse scale rows, and broad naked flange posteriorly ..... 4

- 3b. Scales on top of head reaching posterior nostril; suborbital and premaxilla usually with scales posteriorly; margin of suborbital finely denticulate; preopercle with 5–9 transverse scale rows, and narrow naked flange posteriorly (W. Indian Ocean) ..... *P. townsendi*
- 4a. Dorsal fin with black blotch at base of middle of fin (N.W. Indian Ocean) ..... *P. aspinosa*
- 4b. Dorsal fin without black blotch at base ..... 5
- 5a. Gill rakers on first arch 11–12; pectoral fins with diffuse black spot dorsally on base (Sri Lanka) .  
..... *P. capitinis*
- 5b. Gill rakers on first arch 8–10; pectoral fins without black spot on base ..... 6
- 6a. Dorsal fin with blood red spot between sixth and tenth dorsal spines (lost in preservative); three vertical, dark orange bands on back (E. and W. coasts of India) ..... *P. boesemani*
- 6b. Dorsal fin without red spot; four broad, dark reddish bars on back (E. Indian Ocean and W. Pacific) ..... *P. inermis*

#### ACKNOWLEDGMENTS

The authors thank the skippers and the leaders of the August and September 1998 cruises of the Fishery Survey of India vessel MFV *Matsya Vishwa*. We thank Dr M. F. Gomon and Dr H. K. Larson for their critical comments on the manuscript.

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Accepted 2 October 2002



## The Mygoora Local Fauna: a late Quaternary vertebrate assemblage from central Australia

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### ABSTRACT

The Mygoora Local Fauna (new name) from Mygoora Lake, central Australia (southern Northern Territory), consists of the fossilised remains of 12 vertebrate species referable to modern taxa. The assemblage includes eight marsupials (*Bettongia lesueur*, *Dasyurus cristicauda*, *Dasyurus geoffroyi*, *Lagorchestes hirsutus*, *Lasiiorhinus* cf. *latifrons*, *Macropus rufus*, *Macrotis lagotis*, and *Sarcophilus harrisii*), two rodents (*Notomys alexis* and *Rattus villosissimus*), and two reptiles (*Varanus* sp. and a pythonid, *?Boilrochilus* sp.). *Lasiiorhinus* sp. (hairy-nosed wombat) is a first record of the genus in the Northern Territory, while *Sarcophilus harrisii* (Tasmanian devil) is a first record for central Australia, both records representing extensions of prehistoric ranges for these species. Four species (*Bettongia lesueur*, *Dasyurus geoffroyi*, *Lagorchestes hirsutus* and *Macrotis lagotis*) became regionally extinct in historical times. The fauna is dominated by fossorial species, or species known to occupy existing burrows, that are typical of the Australian arid biogeographic zone. Articulated skeletal remains were preserved in burrows dug into stabilised aeolian sand, with subsequent deflation resulting in localised concentrations of durable fragments at the present land surface. An optically stimulated luminescence (OSL) date of the host aeolian sand provides a maximum age of between 12.1±0.5 and 9.3±0.6 ka for the assemblage. A minimum age could not be determined, but biochronological data suggest that the fauna is possibly of latest Pleistocene or early Holocene age.

**KEYWORDS:** Mygoora Local Fauna, Northern Territory, Australia, late Quaternary, marsupials, rodents, reptiles, *Sarcophilus*, *Lasiiorhinus*, new records, optically stimulated luminescence date.

### INTRODUCTION

Mineralised vertebrate remains were found in 1998 at two sites on the western margin of Mygoora Lake, central Australia (Fig. 1) by P.K.L. in the course of botanical surveying. The sites, which are about 1 km apart, are in deflated aeolian dunes near latitude 25°20' S, longitude 132°40' E. Precise positional information is held on file at the Museum and Art Gallery of the Northern Territory (MAGNT), Darwin. Fossils from the more northerly site, distinguished here as Site 2, are here formally designated the type assemblage of the Mygoora Local Fauna (LF).

Based on an analysis of diagnostic (primarily cranial) remains from the type locality, the Mygoora LF is shown to consist of extant species of Varanidae, Boidae, Dasyuridae, Thylaeomyidae, Vombatidae, Potoroidae, Macropodidae and Muridae. The type assemblage, whose geological age is constrained by

optically stimulated luminescence (OSL) dating and biochronological considerations to the late Quaternary (probably latest Pleistocene or early Holocene), adds to knowledge of the late Quaternary history of the central Australian fauna (e.g. Copley *et al.* 1989, Baynes and Baird 1992, Baynes and Johnson 1996).

Material from the type locality (Site 2) is held in the MAGNT palaeontological collection under batch number P2663-. Material from Site 1 was scanned to establish whether there were any taxa present that were not also represented at Site 2. None were identified. The Site 1 material, held under batch number P2664-, was not further analysed and is not documented here.

The taxonomy of the Mygoora Lake fossil assemblage was determined by comparison with neontological reference material held in the MAGNT. Because the fauna consists of modern species, no anatomical descriptions are provided. Rather, the fossil assemblage is analysed in terms of its taphonomy and preservational

state, and the ecology and present distributions of represented species. Two species, the Tasmanian devil, *Sarcophilus harrisii* and a hairy-nosed wombat, *Lasiorhinus* sp., are extralimital with respect to their modern distributions. The *Lasiorhinus* is a new record for the Northern Territory. *Sarcophilus harrisii* is depicted in Arnhem Land Aboriginal rock art, and skeletal remains radiocarbon dated at  $3120 \pm 100$  years before present have been found in association with an archaeological deposit just to the west of Arnhem Land (Calaby and White 1966; Calaby and Lewis 1977), but *S. harrisii* has not previously been reported from central Australia.

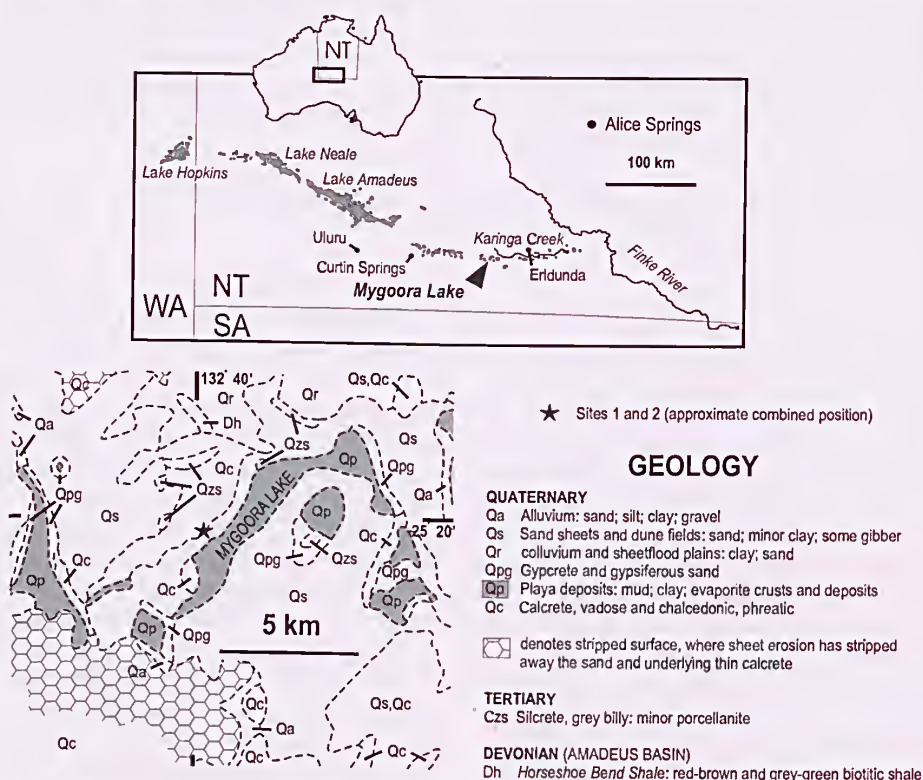
## STRATIGRAPHY AND AGE

**Depositional and stratigraphic setting.** The following account of the depositional and stratigraphic setting of the Mygoora Lake fossil deposit follows Arakel and Wakelin-King (1991) and Edgoose *et al.* (1993).

Mygoora Lake is a playa in a chain extending 500 km from Lake Hopkins in the central far east of Western Australia, east to the central southern part of the Northern Territory (Fig. 1). The playas define the drainage axis of an un-named elongate Cainozoic sedimentary basin developed upon, and confined by,

folded and fractured Neoproterozoic to Palaeozoic sedimentary rocks of the Amadeus Basin. During the Tertiary, palaeodrainage was into Lake Eyre via the Finke River. Today, however, surface and shallow groundwater flow is internal, with the chain of playas almost completely isolated from the Finke River by aeolian sand.

Tertiary rocks of the Cainozoic basin include valley-fill deposits (coarse sandstone, siltstone and minor marl) and talus and scree, capped by a resistant silcrete duricrust attributed to several episodes of silicification. Siliceous duricrust also formed on exposed Palaeozoic strata, and subsequent dissection has resulted in remnant low mesas and buttes. A veneer of Quaternary aeolian quartz sand, playa deposits, alluvium, calcrete, gypcrete and gypsiferous sand otherwise blankets most of the older strata. Of particular relevance to this report are aeolian sand and calcrete that occur around Mygoora Lake (Fig. 1). The calcrete, mostly obscured by transported sand, resulted from two Late Pleistocene formational episodes, dated by electron spin resonance (ESR) at Curtin Springs, about 90 km west of Mygoora Lake. The earlier phreatic calcrete, dated at 75–34 thousand years (ka) before present, formed beneath the water table along drainage lines, while the later vadose calcrete formed at 27–22 ka by evaporation in groundwater discharge zones, especially at the margins



**Fig. 1.** Locality diagrams and geology of the Mygoora Lake area, taken from the Kulgera SG/53-5 1:250,000 Geological Sheet (Edgoose *et al.* 1993).





**Fig. 2.** Site 2: A, general view of the deflated area producing fossil remains; B, surface lag composed of bone fragments (light particles) and rhizoconcretionary clasts (dark particles). C, occluded dentition of *Sarcophilus harrisi* *in situ*. D, partially excavated articulated legs of *Bettongia lesueur* found with only the terminal phalanges exposed at the surface. The femur and proximal part of the tibia has partly weathered away. E, a second *B. lesueur* skeleton. Note the vertical orientation of the tibia, the broken shaft of which projected to the surface. The skull is to the left. F, same specimen as in E after further excavation, showing a rhizoconcretion *in situ*.

of playas. The overlying fine to medium quartz sand, now partly stabilised by vegetation, forms sheets and longitudinal dunes with relief of up to 12 metres. Individual grains are coated by ferruginous clay that imparts the red colour typical of central Australian desert sands. Playa sediments typically consist of brown and green mud containing evaporites (predominantly gypsum), with a crust of halites and other soluble minerals. These muds are derived from the underlying Horseshoe Bend Shale (Devonian) of the Amadeus Basin.

**Occurrence of vertebrate fossils.** Vertebrate remains were found on deflated dune surfaces (Fig. 2A) at two localities (Sites 1 and 2, Fig. 1) on the western margin of Mygoora Lake. Well-indurated but fragmentary bones rarely more than a couple of centimetres long, and rhizoconcretions, form a surface lag at these sites (Fig. 2B). Amongst the surface fossils there is a preponderance of durable elements such as mammal teeth and jaw fragments. At Site 2, within an area of several hundred square metres, several more complete specimens were found protruding from the surface, and

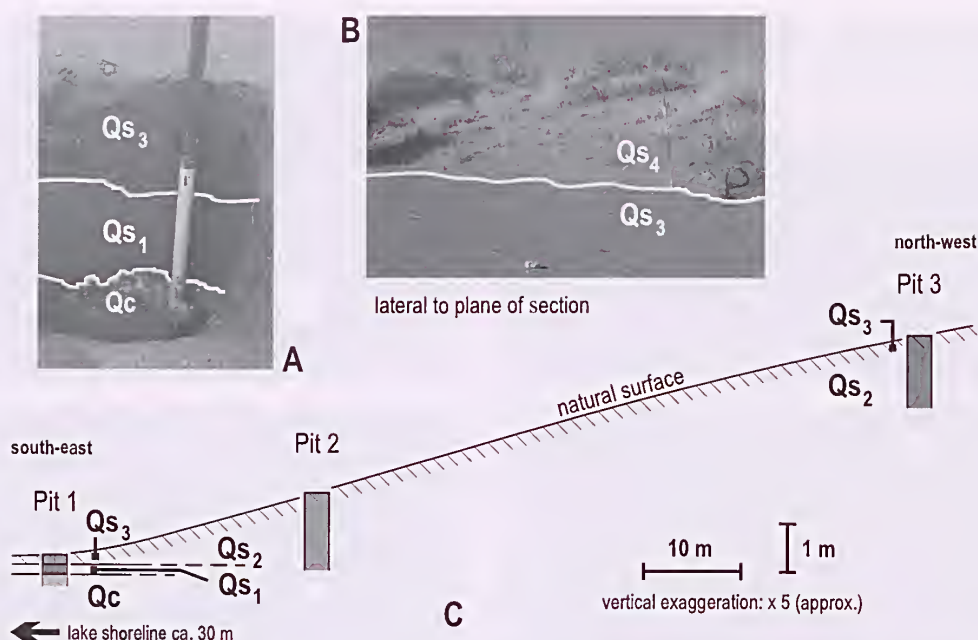


Fig. 3. Summary of stratigraphy at Site 2. A, schematic cross-section showing relationships of strata; B, stratigraphy in Pit 1; C, stratigraphy lateral to the line of section, showing the lighter coloured sand of the active (modern) dune system overlying the older aeolian sands.  $Qs_{1-4}$  are informal members of mapping unit Qs of the regional geology (Figure 1; note also Qc), as described in the text.

excavation revealed them to be parts of articulated remains (Figs 2C–F). No such specimens were found at the less extensive Site 1. Some parts of the skeletons excavated at Site 2 had weathered away *in situ*, but other parts are well preserved.

Some exploratory excavation was carried at Site 2 in a search for more articulated skeletons, and, as described below, three shallow stratigraphic pits were also dug. The excavated material was screened to try to ascertain the frequency of rhizoconcretions and skeletal remains within the sediment. However, no additional skeletal material was found in the course of these activities, and rhizoconcretions (Fig. 2F) were found to be very sparse. The indications are that the surface lag (i.e. bone fragments and rhizoconcretions) at both sites have resulted from the deflation of a substantial, but unknown, volume of sediment.

**Stratigraphy at Site 2.** The stratigraphy at Site 2 is summarised in Figure 3. The local succession consists of carbonate-cemented clayey sand succeeded by red aeolian sand, representing respectively units Qc and Qs of the regional geology (Fig. 1). Qs is here differentiated into four informal members designated  $Qs_{1-4}$ . The two lowest stratigraphic units, Qc and  $Qs_1$ , were intersected only in Pit 1.

Qc (Figs 3, 4A) consists of hard, carbonate-cemented sandstone, mottled very pale orange (10YR 8/2), greyish orange (10YR 7/4), light brown (5YR 6/4) and moderate brown (5YR 4/4). Only the top 200 mm of the unit was intersected in Pit 1. The sand

fraction is predominantly quartz, with calcrite clasts, feldspar grains, lithic quartz and an opaque mineral (?magnetite) as minor constituents. The sand grains are poorly sorted (very fine to coarse), and range from angular to well rounded. Quartz grains are commonly embayed and/or etched, and are rimmed by goethite that is thicker over embayments in the grains. Primary porosity is filled with micrite with ferruginous and clay inclusions. No sedimentary structures or fossils were observed. The poor sorting, coarse texture, presence of angular grains, and compositional range suggest that the sediment represents localised alluvial reworking of older beds, diagenetically cemented by calcium carbonate and iron compounds. Qc is succeeded in Pit 1 by  $Qs_1$  (fine, red sand) across a sharp, irregular contact representing an erosional unconformity.

$Qs_1$  is a thin (200 mm) bed of weakly consolidated, massive, unfossiliferous, reddish brown (between moderate reddish brown 10R 4/6 and light brown 5YR 5/6), well-sorted, fine quartz sand. This unit was only recognised in Pit 1, and its extent is not known (Fig. 3). Grains are sub-rounded to rounded and rimmed by goethite, characteristic of 'red' aeolian sands of central Australia. Highly localised void-filling iron compounds (Fig. 4B, inset) may account for both the incipient state of lithification, and the redder hue compared to the next two units ( $Qs_2/Qs_3$ ) of the succession.

In Pit 1,  $Qs_1$  is succeeded by  $Qs_3$  across an irregular, erosional contact (Fig. 3). The unconformable succession across this contact is supported by



geochronological evidence presented below.  $Qs_3$  is a light brown (5YR 5/6), fine quartz sand, texturally indistinguishable from  $Qs_1$  (compare Fig. 4B and 4C), containing rhizoconcretions and vertebrate remains (Fig. 2). In Pits 2 and 3, on the other hand, the rhizoconcretionary horizon is underlain by apparently barren sand of identical colour which is here distinguished as  $Qs_2$ . As discussed below,  $Qs_2$  and  $Qs_3$  are considered to be the same depositional unit, with the latter representing a pedogenic horizon related to an ancient land surface. The transition from  $Qs_2$  to  $Qs_3$  is indistinct.

The stratigraphic succession at Mygoora Lake culminates in  $Qs_4$ , the unconsolidated, lighter coloured (moderate reddish orange, close to 10R6/6) fine sand of the modern dune system (Fig. 3).

**Geochronology.** Two samples, one each from units  $Qs_1$  (field identification ML1) and  $Qs_3$  (ML2) were collected from Pit 1 for dating by optically stimulated luminescence, which was carried out by Drs J.R. Prescott and F.M. Williams at the Department of Physics and Mathematical Sciences, Adelaide University. Methods and results presented below are as reported by J.R. Prescott (written comm., 7 April, 2000; sample laboratory codes AdGL00001 and AdGL00002); comments by Dr Prescott in the Results section pertaining to the possible geological history of the samples are reviewed in the Discussion that follows.

**Methods.** Ages were determined using green light stimulation of quartz grains in the size range 90–125  $\mu$ m. Quartz grains of this size were separated using standard techniques (Huntley *et al.* 1993). Equivalent doses were obtained using the Australian Slide method (Prescott *et al.* 1993), and total dose rates were obtained using thick source alpha counting (U and Th) and X-ray fluorescence spectrometry (K). These laboratory methods give a reasonable measurement of the dose rate, though field scintillometry at the time of sampling is desirable in addition. Cosmic ray dose rates were determined from the relationship between

depth, density and cosmic ray penetration established by Prescott and Hutton (1994).

**Results.** Ages were calculated using Grün's AGE programme (commercial, version 1999) and are shown, together with relevant data, in Table 1. Major element analyses obtained by X-ray fluorescence spectrometry are also included.

In determining total dose rates, an allowance must be made for the water content of the material as water absorbs part of the radiation that that would otherwise reach the grains. This poses a problem when dealing with lake sediments (see discussion below) as the lake was presumably full and the sediment saturated at the time of deposition. The water content would subsequently vary with time as the lake dried out. We have therefore provided age determinations for two extremes of water content: saturation and present day content. It is evident from Table 1A that this introduces a considerable uncertainty in the ages. [Sample ML1 (= unit  $Qs_1$ ):  $32.0 \pm 2.8 - 24.0 \pm 2.1$  ka. Sample ML2 (= unit  $Qs_3$ ):  $12.1 \pm 0.5 - 9.3 \pm 0.6$  ka].

**Discussion.** The poor sorting and presence of large clasts (up to coarse sand grade in thin-section) in Qc is consistent with alluvial deposition, with the micritic clasts probably representing reworked calcrete. The Qc bed was not dated, but its minimum age is constrained to  $32.0 \pm 2.8 - 24.0 \pm 2.1$  ka by the overlying unit,  $Qs_1$ . The calcrete clasts may be attributable to the regional, phreatic calcrete formation-event of 75–34 ka, while induration of the unit by carbonate cementation may be attributable to the vadose formation-event of 27–22 ka identified by Edgoose *et al.* (1993) and Arakel and Wakelin-King (1991). Petrography and geochronological attributes of the unit are concordant with unit Qc of the regional geology.

All members of Qs at Mygoora Lake have the textural attributes of aeolian sand. As described above, the oldest member at Mygoora Lake,  $Qs_1$ , is weakly consolidated, in contrast to the younger units. Units  $Qs_1$  and  $Qs_3$  produced very similar compositional

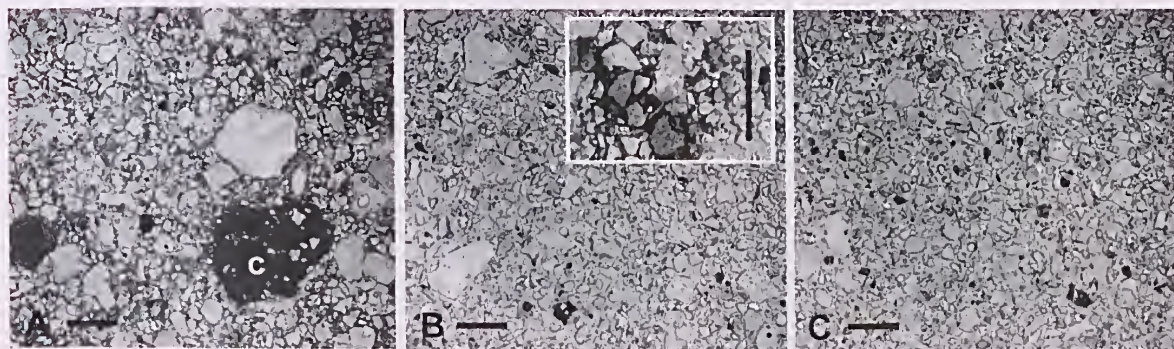


Fig. 4. Photomicrographs of samples from Pit 1; all plane polarised light; scale bars = 1 mm. A, unit Qc (thin section TS 0526), coarse, carbonate-cemented, mottled sandstone; reworked calcrete clast labelled 'c'. B,  $Qs_1$  (TS 0527), weakly-consolidated, fine, red sand. INSET (TS 0528) – zones of iron enrichment (cementation) may account for the incipient lithification of the unit, and deeper red colour compared to the texturally-identical overlying unit,  $Qs_3$ . C,  $Qs_3$  (TS 0529), fine red sand of the fossiliferous unit.

**Table 1.** Optically stimulated luminescence and geochemical analyses. A, relevant measurements, dose rates and ages. <sup>1</sup> It was noted during preparation that the material contains a large amount of clay. This would account for the high overall potassium content. <sup>2</sup> Expressed as % dry weight. B, major element analyses obtained by X-ray fluorescence spectrometry. Samples were dried at 110° C for ~2 hours (not pre-ignited), then weighed with a flux and fused to form glass discs. The difference from 100% in the total is the loss on fusion. K<sub>2</sub>O values provided to 3 decimal places, but significant to only 2. (J.R. Prescott, written comm. 7 April, 2000)

## A

Sample (Laboratory code)	Th content (ppm)	U content (ppm)	K content <sup>1</sup> (%)	Cosmic radiation (Gy ka <sup>-1</sup> )	H <sub>2</sub> O content <sup>2</sup> (p) present day (s) saturation	Total dose rate (Gy ka <sup>-1</sup> ) (p) present day H <sub>2</sub> O (s) saturation H <sub>2</sub> O	Equivalent dose (Gy)	Age (ka) (p) present day (s) saturation
ML1 (AdGL000001)	7.21±0.35	0.72±0.03	1.81±0.05	0.150±0.020	(p) 4.3±1.0 (s) 36.0±2.0	(p) 2.50±0.07 (s) 1.87±0.05	60.0±5.0	(p) 24.0±2.1 (s) 32.0±2.8
ML2 (AdGL000002)	6.32±0.20	0.53±0.02	1.78±0.00	0.160±0.020	(p) 3.1±1.0 (s) 32.0±2.0	(p) 2.41±0.04 (s) 1.84±0.04	22.3±1.1	(p) 9.3±0.5 (s) 12.1±0.6

## B

Sample	SiO <sub>2</sub> %	Al <sub>2</sub> O <sub>3</sub> %	Fe <sub>2</sub> O <sub>3</sub> %	MnO %	MgO %	CaO %	Na <sub>2</sub> O %	K <sub>2</sub> O %	TiO <sub>2</sub> %	P <sub>2</sub> O <sub>5</sub> %	SO <sub>3</sub>	LOI %	Total %
ML1	87.36	4.88	2.26	0.04	0.46	0.20	0.40	2.185	0.58	0.03	0.00	0.00	98.40
ML2	87.82	4.38	2.01	0.04	0.25	0.72	0.41	2.145	0.56	0.05	0.01	0.00	98.40



analyses (Table 1B). The only factor that can be identified as possibly accounting for the contrasting mechanical properties is the slightly higher iron content of  $Qs_1$  compared to  $Qs_3$ , which is also reflected in the redder hue of  $Qs_1$ ; quartz grains in  $Qs_1$  may be weakly cemented together by iron compounds. Although  $Qs_1$  overlaps in possible age ( $32.0 \pm 2.8 - 24.0 \pm 2.1$  ka; Table 1A) with that of the possible age of the regional vadose calcrete forming-event ((27–22 ka: Arakel and Wakelin-King (1991), Edgoose *et al.* (1993)), the indications are that  $Qs_1$  was not affected by it, and therefore post-dates it. There is no contrast in loss on fusion (which may be used as a proxy for loss on ignition of carbonate, including any that might be present as cement) between  $Qs_1$  and  $Qs_3$ , dated at  $12.1 \pm 0.5 - 9.3 \pm 0.6$  ka (Table 1A).

The uncertainty in the luminescence dates of  $Qs_1$  and  $Qs_3$  is related to their history of the degree of saturation by water since their deposition, as outlined above.  $Qs_1$  and  $Qs_3$  of stratigraphic Pit 1 were deposited at the lake margin, rather than within it. The lake represents local base-level for shallow groundwater discharge, and during periods of lake highstand, the water table might have risen sufficiently to saturate  $Qs_1$  (and  $Qs_3$ ) in Pit 1. However, nothing was observed to suggest that these sediments were covered and reworked by lake waters (e.g. sedimentary structures indicative of hydraulic working, or elevated ancient strandlines). If lake levels failed to reach such heights as to cover and saturate the sediments at Pit 1 for prolonged periods, younger rather than older ages for  $Qs_1$  and  $Qs_3$  seem more likely.

Member  $Qs_3$  provides only a maximum age of the vertebrate fauna. As detailed below, the vertebrate fauna recovered from  $Qs_3$  is characterised by fossorial animals, or those known to occupy burrows dug by other species, and/or animals that might have been taken as prey by animals that occupy burrows.  $Qs_3$  is distinguished from  $Qs_2$  only by its diagenetic features, particularly the presence of rhizoconcretions and the remains of vertebrates probably introduced post-depositionally. These features are indicative of the close proximity of a natural land surface.  $Qs_3$  and  $Qs_2$  occupy the same stratigraphic position with respect to overlying ( $Qs_4$ ) and underlying (Qc) strata, and  $Qs_3$  is simply a diagenetic facies (a soil by virtue of its pedogenic features, namely rhizoconcretions) of  $Qs_2$  which developed below the natural surface. The lag of fossils and rhizoconcretions at Sites 1 and 2 is the product of deflation of all or most of  $Qs_3$ .

## SYSTEMATIC PALAEONTOLOGY

More than 1000 cranial and postcranial specimens, representing an estimated minimum number of 125 individual animals ranging in size from small rodents

to red kangaroos, were collected at Site 2. The Mygoora Local Fauna contains 12 species of vertebrates of which all but two are mammalian, as summarised in Table 2. Four taxa, *Dasyurus geoffroii*, *Sarcophilus harrisii*, *Lasiiorhinus* sp. and *Bettongia lesueur* are now regionally extinct. Remains of two species of introduced mammals, the dingo, *Canis familiaris*, and the rabbit, *Oryctolagus cuniculus*, were present in the surface collections, but are distinguished from the Mygoora Local Fauna by their unmineralised state.

While the great majority of specimens were collected from the surface, some complete and partial articulated skeletons were found *in situ* and recovered by excavation, as described above. The surface collections consist of fragments of the most durable skeletal elements, only a few of which preserve articulation. Complete ankle joints of small macropodoids, sections of occluded upper and lower dentitions, and articulated vertebral segments support the observations that the primary deposition consisted of complete or partial carcasses.

The following species list is annotated with brief descriptions of the diagnostic material, and ecological and biogeographic notes abstracted from Strahan (1991) and Brown (1974), unless otherwise acknowledged.

**Table 2.** The Mygoora Local Fauna. Higher-level mammalian systematics follows Aplin and Archer (1987). † indicates species that became locally extinct in historical times, and †† indicates species that became locally extinct in prehistoric times.

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Class Reptilia
* Order Squamata
Suborder Sauria
Family Varanidae
<i>Varanus</i> sp.
Suborder Ophidia
Family Boidae
? <i>Bothrochilus</i> sp.
Class Mammalia
Supercohort Marsupialia
† Order Dasyuromorphia
Family Dasyuridae
<i>Dasyurus cristicauda</i>
<i>Dasyurus geoffroii</i> †
<i>Sarcophilus harrisii</i> ††
Order Peramelomorphia
Family Thylacomyidae
<i>Macrotis lagotis</i> †
Order Diprotodontia
Family Vombatidae
<i>Lasiiorhinus</i> sp. ††
Family Potoroidae
<i>Bettongia lesueur</i> †
Family Macropodidae
<i>Lagorchestes hirsutus</i> †
<i>Macropus rufus</i>
Supercohort Placentalia
Order Rodentia
Family Muridae
<i>Notomys alexis</i>
<i>Rattus villosissimus</i>

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***Varanus* sp. — monitor lizards**

Small to medium-sized *Varanus* are represented by some mandible fragments and four vertebrae. While at least two individuals are present, the material is inadequate for specific determination (Fig. 5).

***Bothrochilus* sp. — pythons**

A short articulated vertebral series and isolated vertebrae indicate the presence of small pythons (Fig. 6) probably belonging to *Bothrochilus* (*B. childreni* group). Possibly more than one individual is represented as the elements were widely dispersed. Small to medium-sized pythons belonging to the *B. childreni* group are common elements in the present day central Australian fauna, preferring woodlands lining drainage systems and often sheltering in abandoned burrows.

***Dasyurus geoffroii* — western quoll**

Western quolls are indicated by fragments of right and left dentaries with  $M_{1,3}$  and left maxillary  $M^{1-2}$  (Fig. 7A–B, G). Differences in the depths of the mandibles and molar wear on the specimens indicate a minimum of two individuals in the sample (Table 3). The western quoll is well adapted to arid conditions and until recently, lived in a wide range of habitats. The species is now confined to south-western Western Australia and Papua New Guinea and is probably extinct in inland Australia.

***Dasymercus cristicauda* — mulgara**

The mulgara is the most abundant dasyurid in the Mygoora Local Fauna with a minimum of six individuals estimated from dentaries (Fig. 7C–F, H–I). Mulgaras prefer arid sandy habitats, living in burrows of varied complexity. At present mulgaras are common in the central Australian region of the Northern Territory.

***Sarcophilus harrisii* — Tasmanian devil**

The Mygoora Lake *Sarcophilus harrisii* specimens (Fig. 8) provide the first record of Tasmanian devils within the central Australian part of the arid zone. A young individual is represented by upper cheektooth rows and associated lower jaws recovered *in situ* (Fig. 8A–B). One or more mature individuals are also indicated by isolated upper and lower canines, a heavily worn left  $M^1$  and an isolated, heavily worn right  $M_1$  (Fig. 8C–F). The occluded, lightly worn dentition of the immature specimen includes upper and lower canines to  $M_3$  and  $M^2$  on the left, and upper and lower canines to  $M_2$  and part of  $M^3$  on the right. The presumably encrypted posterior molars have been lost.

Tasmanian devils have been recorded from numerous mainland Australian Quaternary sites, including one in the Top End of the Northern Territory (Calaby and White 1966), and are depicted in prehistoric Arnhem Land and Kimberley rock art (Calaby and Lewis 1977). Remains of Tasmanian devils in south-western Victoria

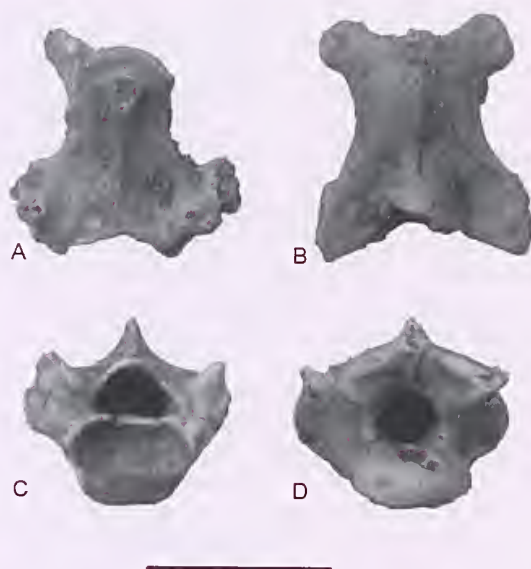


Fig. 5. Vertebra of *Varanus* sp., monitor lizard, Mygoora LF. A, ventral; B, dorsal; C, anterior; and D, posterior views. Scale bar = 1 cm.

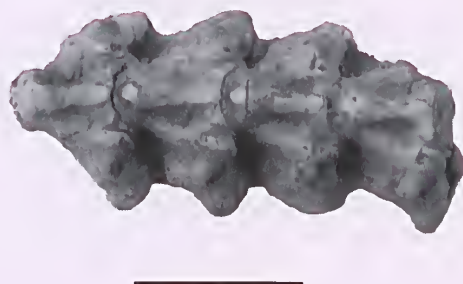


Fig. 6. Vertebral series small python, ?*Bothrochilus* sp. (ventral view, anterior to the left), Mygoora LF. Scale bar = 1 cm.

Table 3. Estimated minimum number of individuals (MNI) and relative abundance of mammalian species in the Mygoora LF.

Species	MNI	Relative Abundance %
<i>Dasymercus cristicauda</i>	6	5.0
<i>Dasyurus geoffroii</i>	2	1.7
<i>Sarcophilus harrisii</i>	2	1.7
<i>Macrotis lagotis</i>	3	2.6
<i>Lasiorhinus</i> cf. <i>latifrons</i>	1	0.9
<i>Bettongia lesueur</i>	76	66.0
<i>Lagorchestes hirsutus</i>	15	13.0
<i>Macropus rufus</i>	1	0.9
<i>Rattus villosissimus</i>	6	5.0
<i>Notomys alexis</i>	4	3.0



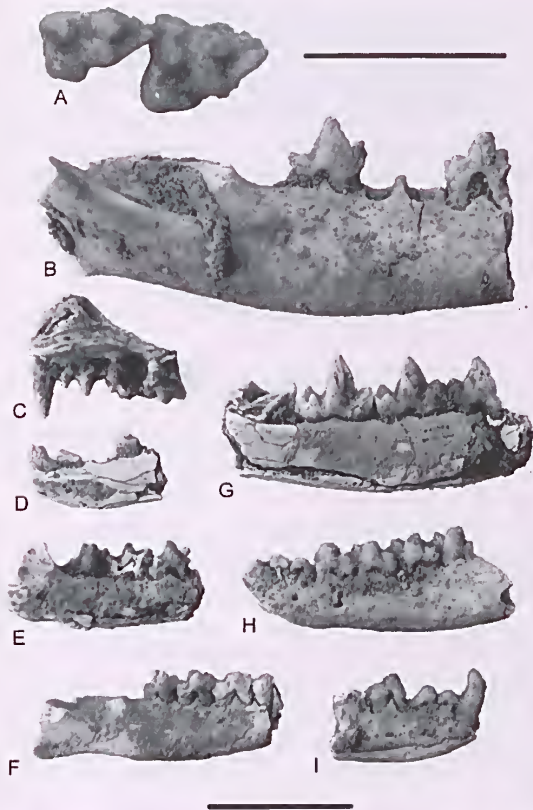


Fig. 7. Selected specimens of Dasyuridae, Mygoora LF: A, left  $M^{1-2}$  of western quoll, *Dasyurus geoffroii*, enlarged, 1 cm scale to right; B, right dentary fragment of *Dasyurus geoffroii* with right  $M_2$  and  $M_3$ ; C, right maxilla of mulgara, *Dasycercus cristicauda* with  $C^1-M^2$ ; D, right dentary fragment of *Dasycercus cristicauda* with C-M $_1$ ; E, right dentary of *Dasycercus cristicauda* with  $M_{2-4}$ ; F, right dentary of *Dasycercus cristicauda* with  $M_{1-4}$ ; G, left dentary of immature *Dasyurus geoffroii* with  $M_{1-4}$ ; H, left dentary of *Dasycercus cristicauda* with C-M $_1$ ; I, right dentary fragment of *Dasycercus cristicauda* with C-M $_2$ . Scale bars: A, 1 cm; B-I, 1 cm.

date to as recently as 600 years B.P. Though presently confined to the cool, temperate climate of Tasmania, *S. harrisii* occurred in semi-arid parts of western New South Wales and South Australia during the Pleistocene (Dawson 1982), and in the arid southern periphery of Western Australia (Baynes 1987). Length and width measurements of first and second molars from Mygoora Lake lie close to the regression lines for Late Pleistocene devils, and cluster with the smaller forms referred to *S. harrisii* (Fig. 9). The upper molars fall just slightly below the lower range for extant Tasmanian devils given in Dawson (1982), but their slightly narrower widths is attributed to the loss of the bases of the protocones where the teeth have been sheared off. Dimensions of the lower molars fall within the lower range for extant Tasmanian devils. The isolated, though incomplete molar crowns of the other Mygoora Lake devil specimens also correspond in width (within the

lower end of the range) and morphological details to extant Tasmanian devils.

Two, or possibly three Late Pleistocene size morphs (large, small and intermediate) of devils have been recorded from inadequately dated stratigraphic contexts in eastern and southern Australia (Dawson 1982). The largest morph, *Sarcophilus laniarius*, appears to represent a distinct population, while smaller morphs overlap with the lower ranges of molar dimensions of the extant Tasmanian devils and are not distinguishable from them on the basis of available data. The Mygoora Lake devils align with the smaller Pleistocene devils from Lakes Menindee, Garnpung and Tandou, New

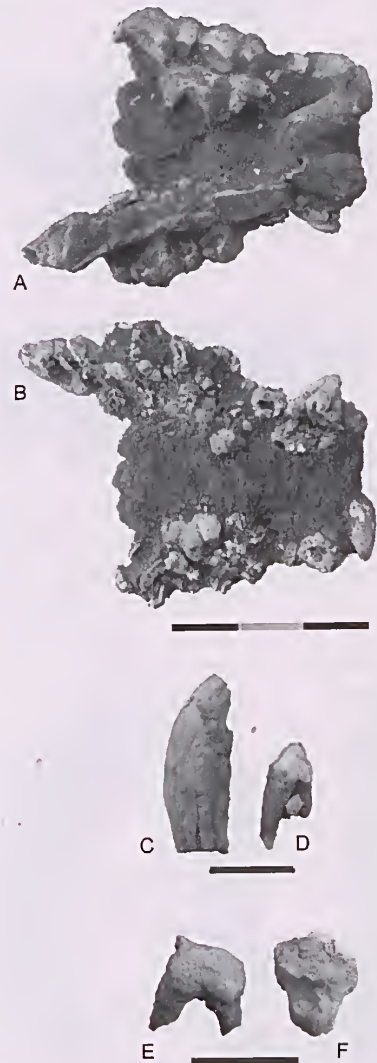


Fig. 8. Associated and isolated teeth of *Sarcophilus harrisii*, Tasmanian devil, Mygoora LF: A, ventral aspect and B, dorsal aspect of upper and lower tooth rows of immature specimen; C, left lower canine and D,  $P_3$ ; E, worn left  $M_1$  and F,  $M^1$ ; scale bar segments = 1 cm.

South Wales, and Dempsey Lakes, South Australia, all of which have recorded semi-arid to arid environments over the last 50,000 years or so of the Pleistocene.

### *Macrotis lagotis* — bilby

The bilby is represented by three dentary fragments and six partial maxillary tooth rows (e.g. Fig. 10) indicating a minimum of three individuals. Once

widespread over inland Australia, the range of the bilby rapidly contracted to scattered populations mainly north of the Tropic of Capricorn in the Northern Territory, western Queensland and east Pilbara and Great Sandy Desert in Western Australia in the early 20<sup>th</sup> Century. Bilbies prefer sandy or loamy substrates with little stone content in which they construct long, deep burrow systems.

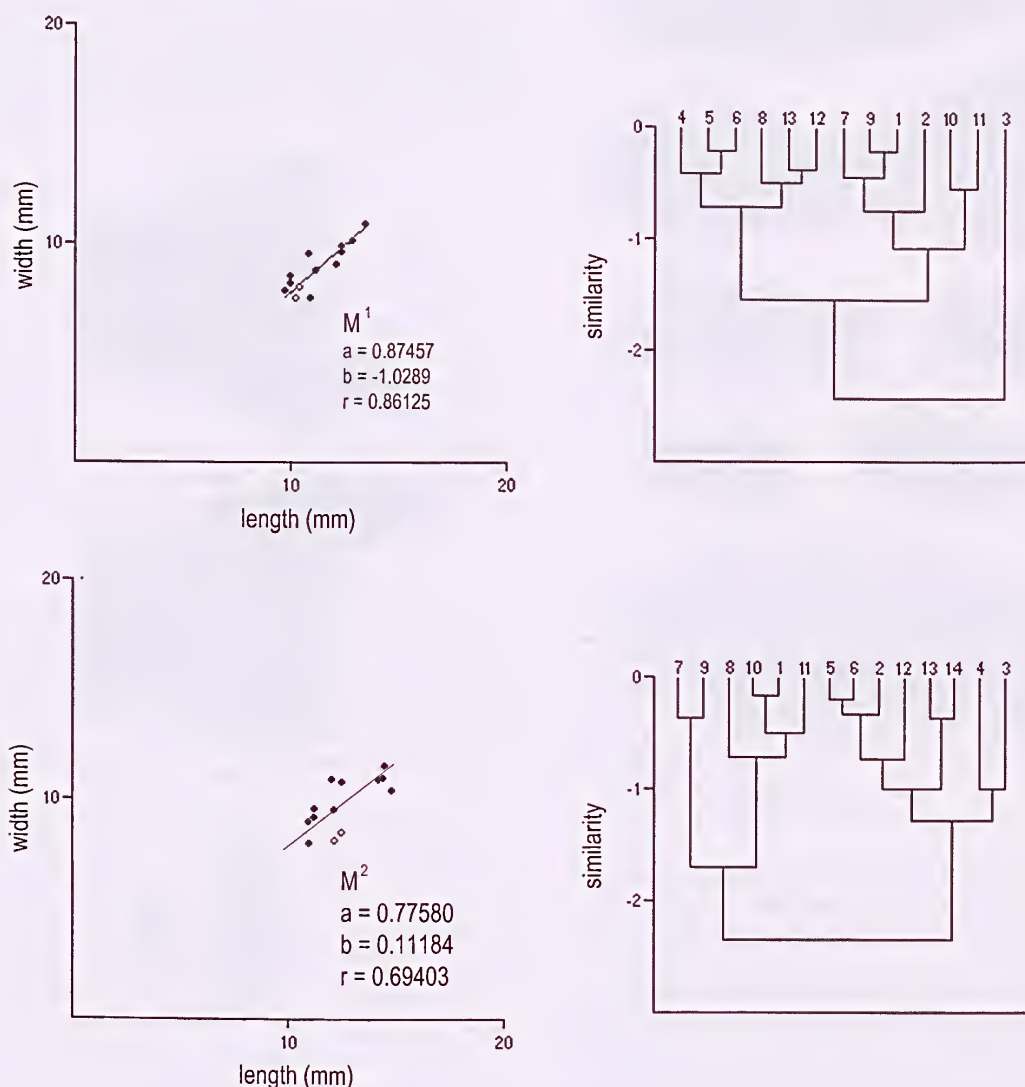


Fig. 9. Bivariate plots with fitted regression lines for length by width of late Pleistocene (solid circles) and Mygoora Lake *Sarcophilus* (open circles) specimens of M<sup>1</sup> (above) and M<sup>2</sup> (below). A clustering algorithm was applied to the variables, yielding a 'similarity tree' for localities, referred to by numerals: above (M<sup>1</sup>): 1, Marmor, Qld; 2, Lake Tandou, NSW; 3, Marmor, Qld; 4, Dempseys Lake, SA; 5, Mairs Cave, SA; 6, Garpung Lake, NSW; 7, Cloggs Cave, (Buchan) NSW; 8, Seton, (Kangaroo Island) SA; 9, East Darling Downs, Qld; 10, Cement Mills, Qld; 11, Queenscliff, Vic.; 12, Mygoora Lake, NT; 13, Mygoora Lake, NT; Below: (M<sup>2</sup>): 1, Marmor, Qld; 2, Lake Tandou, NSW; 3, Dempseys Lake, SA; 4, Dempseys Lake, SA; 5, Mairs Cave, SA; 6, Garpung Lake, NSW; 7, Seton, (Kangaroo Island) SA; 8, East Darling Downs, Qld; 9, Cement Mills, Qld; 10, Cement Mills, Qld; 11, Lancefield, Vic.; 12, Queenscliff, Vic.; 13, Mygoora Lake, NT; 14, Mygoora Lake, NT. Mygoora Lake *Sarcophilus* measurements, especially the M<sup>2</sup>, aligns them with Late Pleistocene semiarid inland lake localities (Lakes Tandou, Dempsey and Garpung) and with localities associated with modern fauna only (Mairs Cave, SA; Queenscliff, Vic.). Data from Dawson (1982).





Fig. 10. Specimens of *Macrotis lagotis*, bilby: A, left  $M_{24}$ ; B, right  $P^3$ - $M^3$ . Scale bar = 1 cm.

*Lasiiorhinus* sp. — hairy-nosed wombat

There are no previous records of hairy-nosed wombats in the Northern Territory. The specimens consist of left and right dentary fragments with complete left and right cheektooth rows, left and right lower incisors and a left upper incisor, probably all from one individual (Figs 11, 12). The specimens are indistinguishable from a range of material from the extant Blanchetown, South Australia, *Lasiiorhinus latifrons* population used for comparison. The osteological distinction between the southern hairy-nosed wombat, *Lasiiorhinus latifrons*, and the northern hairy-nosed wombat, *Lasiiorhinus krefftii*, is based on the length of the nasal bones relative to the frontals, features not preserved with the Mygoora Lake specimen; accordingly the present specimens are referred to only as *Lasiiorhinus* sp.

Southern hairy-nosed wombats are presently restricted to a narrow strip of semi-arid to arid habitat in southern South Australia with an annual rainfall of 200–500 mm, but has also been recorded in some cave deposits in the adjacent part of Western Australian (Baynes 1987). Northern hairy-nosed wombats survive as a small colony in southern Queensland but historic records indicate that the species ranged into Victoria and New South Wales. Remains of Late Pleistocene *Lasiiorhinus* have been found in several inland localities as well as Wellington Caves, where the genus was first recognised from fossil material.

Mitochondrial cytochrome-*b* DNA similarity analysis of wombat species indicates that the northern and southern hairy-nosed wombats "... are as closely related as other species known to hybridise in the wild" (Taylor *et al.* 1998). The northern hairy-nosed wombat population possesses 41% of the heterozygosity and 36% of the allelic diversity of a comparable sample of southern hairy-nosed wombats, suggesting that *Lasiiorhinus krefftii* is a recent isolate of a larger

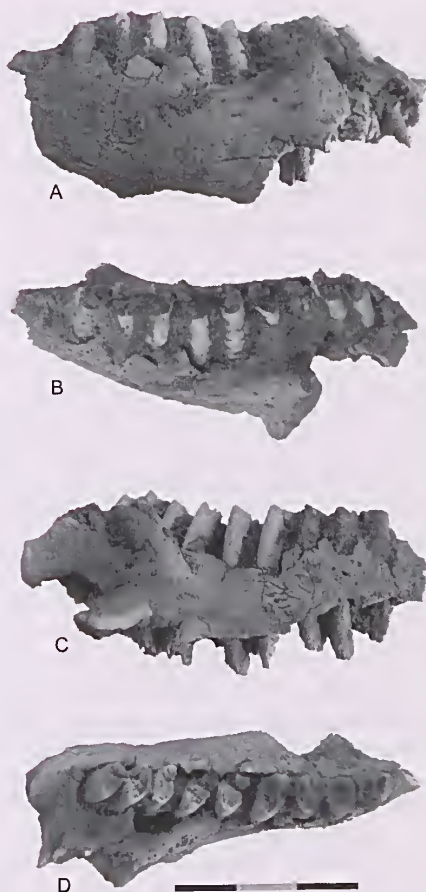


Fig. 11. Dentaries of *Lasiiorhinus* sp., hairy-nosed wombat, Mygoora LF: A, lateral aspect of left dentary; B, occlusal aspect of left dentary; C, right lateral aspect of right dentary; D, occlusal aspect of right dentary. Scale bar intervals = 1 cm.



Fig. 12. Incisors of *Lasiiorhinus* sp., Mygoora LF. A, medial view of right  $I^1$ ; B, left  $I^1$  in ventral view; C, same specimen as B in medial view. Scale bar = 1 cm.

population undergoing a progressive decline in genetic diversity. Dawson (1983) referred all of the Late Pleistocene Queensland and New South Wales hairy-nosed wombats to *Lasiorhinus krefftii*.

Hairy-nosed wombats are colonial and dig extensive, warren-like burrow systems. As sedentary populations, small, widely separated colonies have developed minor osteological and genetic distinctions since the end of the Pleistocene that have been given subspecific or specific status from time to time. None of these is currently recognised for either hairy-nosed wombat species (Dawson 1983).

***Bettongia lesueur* — burrowing bettong**

The burrowing bettong (Figs 13, 14) is the most abundant species in the Mygoora LF with a minimum number of 76 individuals. A complete skull and most of the articulated postcranial skeleton of one individual was recovered by excavation. Once widely distributed and common in all states except Queensland and Tasmania, burrowing bettongs are extinct on mainland Australia, but survive on three small islands off the Western Australian coast. Burrowing bettongs are the only macropodoids that consistently occupy burrows throughout the year and construct extensive, complex and permanent warrens.

***Lagorchestes hirsutus* — rufous hare-wallaby or mala**

Remains of rufous hare-wallabies (Fig. 15) are relatively common elements of the Mygoora LF. A sample of the more intact dentaries indicates a minimum



Fig. 14. *Bettongia lesueur*, burrowing bettong, Mygoora LF: A, skull and B, articulated pes. Scale bar intervals = 1 cm.



Fig. 13. Selected specimens of burrowing bettong, *Bettongia lesueur*, Mygoora LF: A, occlusal aspect of maxilla with left M<sup>1-3</sup>; B, lateral aspect of right maxilla with P<sup>3</sup>-M<sup>1-4</sup>; C, lateral aspect of right dentary with P<sub>3</sub>-M<sub>1-4</sub>; D, medial aspect of left dentary with I<sub>1</sub>-M<sub>2</sub>; E, lateral aspect of left dentary with I<sub>1</sub>-M<sub>4</sub>. Scale bar = 1 cm.



Fig. 15. Specimens of mala, *Lagorchestes hirsutus*, Mygoora LF: A, medial aspect of left maxilla with M<sup>1-4</sup>; B, occlusal aspect of right maxilla with M<sup>1-4</sup>; C, occlusal aspect of right dentary with DP<sub>3</sub>-M<sub>3</sub>; D, lateral aspect of left dentary with P<sub>3</sub>-M<sub>4</sub>. Scale bar = 1 cm.



number of 15 individuals, though many small fragments and individual teeth suggest a larger number, as their crania and mandibles appear to have been less durable than those of *Bettongia lesueur*. Rufous hare-wallabies dig fairly deep burrows during the intense heat of summer, relying on shallower burrows or trenches during the cooler months. Drastic reduction of the once extensive range of *Lagorchestes hirsutus* appears to have followed a pattern similar to that of the burrowing bettong. Small populations survive on several small islands off the Western Australian coast, and attempts have been made to re-establish them in the Tanami Desert. Rufous hare-wallabies prefer semi-arid and arid sand plains with low, woody shrubs or spinifex hummock grasslands for shelter.

#### *Macropus rufus* — red kangaroo

The red kangaroo is represented by left DP<sub>3</sub>, M<sub>2</sub>, protolophid of M<sub>3</sub> and protoloph of left M<sup>2</sup> (Fig. 16). Though widely scattered over the surface collection area, these unworn cheek teeth can be accounted for as the remains of one immature individual.

#### *Notomys alexis* — spinifex hopping mouse

The spinifex hopping mouse is represented by dentary fragments and a maxilla (Fig. 17E, H, I), indicating a minimum number of 4 individuals. The species prefers sandy soils, especially stabilised sandhills into which they excavate deep, multi-entrance burrows. *Notomys alexis* is presently a common species in the central Australian region.

#### *Rattus villosissimus* — long-haired rat

Six individuals of the long-haired rat are represented by dentaries (Fig 17A–D, F–J). Long-haired rats dig shallow complex burrows. Populations of *R. villosissimus* are normally dispersed, but are subject to rapid build-up in favourable conditions.

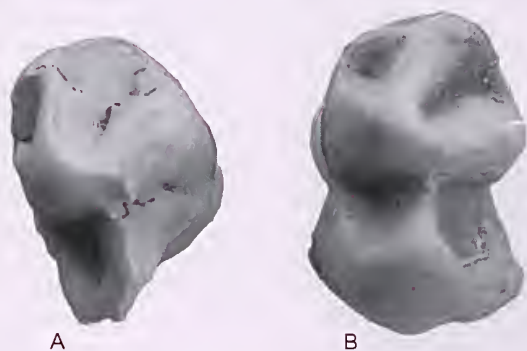


Fig. 16. *Macropus rufus*, red kangaroo, Mygoora LF: A, left protolophid of M<sub>3</sub>; B, left M<sub>2</sub>. Scale bar = 1 cm.

#### Coprolites

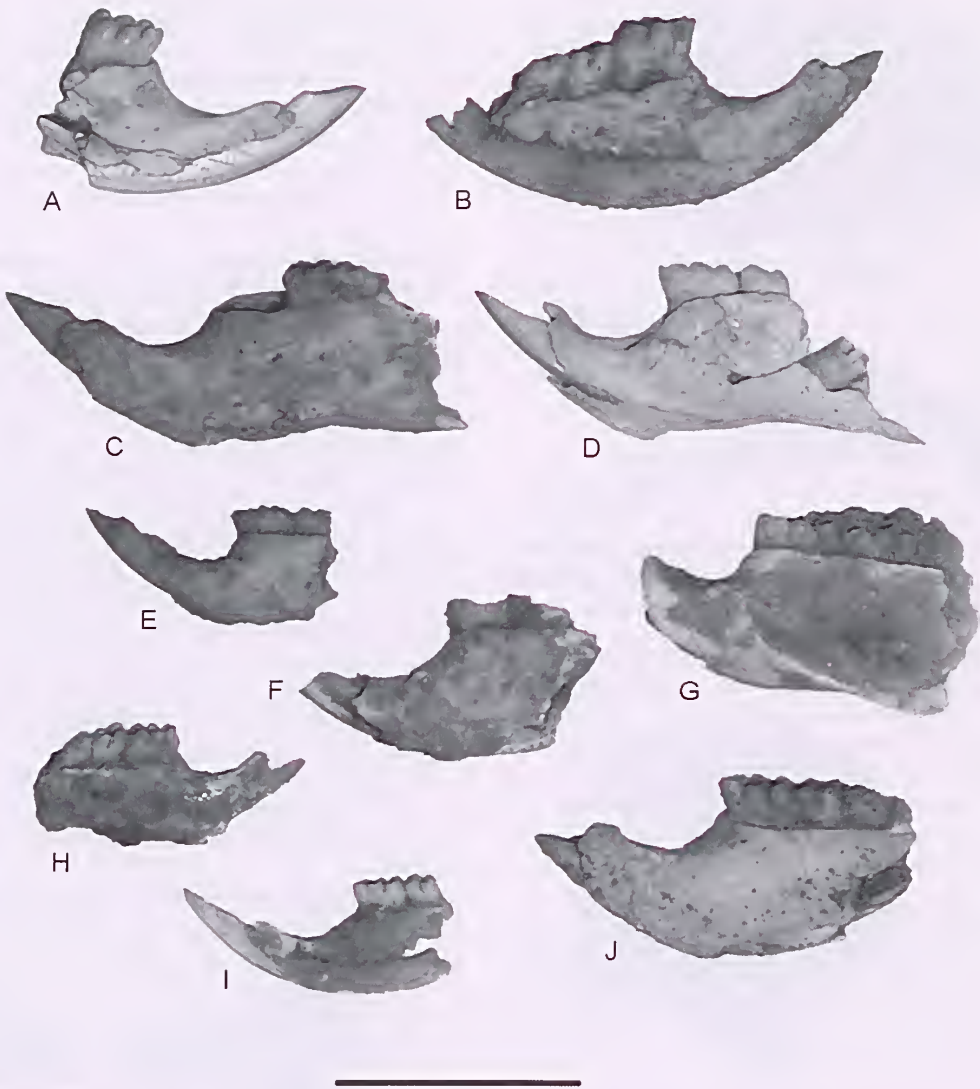
Ellipsoidal aggregates of fragmented bone probably represent scats of devils and/or quolls. The illustrated example (Fig. 18) consists of remains of rodents and small macropodoids, but no species additional to those listed are identifiable.

#### GENERAL DISCUSSION

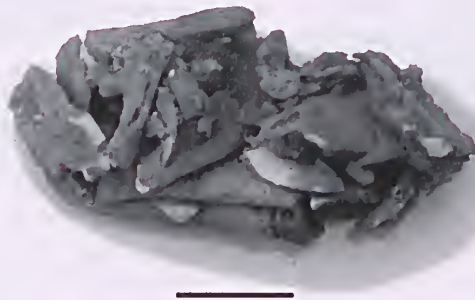
Except for the Tasmanian devil, all other Mygoora LF marsupial species are typical members of the arid, as opposed to the semi-arid, modern continental fauna (Brown 1974) (Fig. 19). Brown (1974) listed 27 species of arid zone marsupials, eight of which (30%) are represented at Mygoora Lake. Thirty-seven per cent of the total arid zone species are burrowers, whereas over 80% of the Mygoora LF sample consists of burrowing forms. Seventy-five per cent of the 20 arid zone species not present in the Mygoora LF are non-burrowing forms. Obviously the Mygoora LF depositional environment was highly selective for burrowing species, of which there are about three times as many in the arid zone fauna as there are in the semi-arid fauna (11%). Consequently, the probability of finding a semi-arid species, had any existed at Mygoora Lake during the depositional interval, is relatively low. On face value, the Mygoora LF represents a typical arid zone fauna adapted to xeric shrublands and tussock grassland within a mean annual precipitation regime of 250 mm or less.

The geographically nearest, comparable prehistoric vertebrate remains were collected from caves and rock crevices at Uluru and Kata Tjuta (Baynes and Baird 1992), located about 200 km west of Mygoora Lake. Attention is also drawn to the complementary works of Copley *et al.* (1989), who analysed bone in owl pellets or loose on the surface below owl roosts during the course of a mammal survey across northwestern South Australia, and Baynes and Johnson (1996). These studies establish which of the mammal species present in the Mygoora LF disappeared from the region in historical times. The large sample of nearly 17,000 mammal bones analysed by Baynes and Baird (1992) included remains of the short-beaked echidna, 22 species of marsupials, 12 species of microchiropteran bats, 10 rodent species and dingos, but the age or ages of these prehistoric assemblages have not been established.

The Uluru bones were accumulated primarily by barn owls (*Tyto alba*) with a small contribution from dingos. While a selective bias related to the size and predatory habits of owls is evident, the assemblage provides the most reliable sample of the Recent vertebrate community in the area at some time before the introduction by Europeans of cats, foxes, rabbits



**Fig. 17.** Dentaries of murid rodents: A–D, F, G and J, dentaries of long-haired rat, *Rattus villosissimus*; E, H–I, dentaries of spinifex hopping mouse, *Notomys alexis*. Scale bar = 1 cm.



**Fig. 18.** Coprolite composed of rodent and small macropodoid bone fragments, Mygoora LF. Scale bar = 1 cm.





Fig. 19. Map delimiting semi-arid and arid faunal zones of Australia, redrawn from Brown (1974); locations of Mygoora Lake and Holocene cave fauna from Uluru caves (Baynes and Baird 1992) are shown as triangles. Light grey tone shows the original (i.e. at about the time of European occupation of Australia) range of *Lasiiorhinus latifrons*, slightly darker tone represents *Lasiiorhinus krefftii* and the dark tone (Tasmania) represents *Sarcophilus harrisii* (after Strahan (1991)).

and grazing ungulates, subsequent to the earlier introduction of the dingo in the mid to late Holocene (Milham and Thompson 1976, Newsome and Coman 1989). Baynes and Baird (1992) identified 33 species of terrestrial mammals (excluding the dingo) compared to 10 from Mygoora Lake (Tables 4, 5). Differences are primarily in the number of smaller species of Muridae and Dasyuridae. Relative abundance (% minimum number of individuals for each species) is similar except for the much higher abundance of burrowing bettongs and malas at Mygoora Lake (Tables 3, 4), data that reflect the respective modes of accumulation at the two localities.

The Uluru assemblage is biased towards relatively small prey-items selected by owls, the Mygoora LF is biased towards species that exhibit fossorial behaviour or occupy borrows made by other animals. The sedimentological evidence indicates that the skeletal remains of such species, plus or including possible prey items selected by carnivores, accumulated within borrows in stabilised acolian dunes. These dunes were subsequently remobilised, the more durable elements becoming locally concentrated by deflation. The Mygoora LF thus includes both articulated remains recovered by digging into undisturbed sediment, as well as more fragmentary material collected from the lag deposits at deflated surfaces.

The Mygoora LF shows that the former range of the Tasmanian devil and hairy-nosed wombat extended well beyond present distributions. All other species are locally extant or have been recorded in the central Australian region since European contact (Copley *et al.* 1989; Baynes and Johnson 1996).

Cluster analysis of dental measurements groups the Mygoora Lake devils with inland Late Pleistocene devil populations from the Simpson Desert and western New South Wales lake regions (Fig. 9). Taking into account the previously known Late Pleistocene and Holocene distributions of *Sarcophilus* in semi-arid and arid palaeohabitats (Dawson 1982; Baynes 1987), the Mygoora LF represents a typical Eyrean vertebrate fauna, which if in any way unusual, is only for its lack of species diversity.

The Mygoora Lake *Lasiiorhinus* sp. suggests the extent to which hairy-nosed wombat populations may have contracted during the Holocene. Because the Mygoora Lake environment is fairly typical of the region, it is possible that the range of *Lasiiorhinus* extended at least 500 km further west along the Tropic of Capricorn.

The former presence of wombats at Mygoora Lake suggests that primary productivity may been somewhat

Table 4. Comparison of relative abundance of species in Holocene Uluru cave deposits (Baynes and Baird 1992) with the Mygoora LF: X = approximately 0–1%; XX = 1–10%; XXX = 10–100% (categories from Baynes and Baird 1992).

Species	Uluru	Mygoora LF
<i>Dasyurus cristicauda</i>	XX	XX
<i>Dasyurus geoffroii</i>	X	X
<i>Sarcophilus harrisii</i>	—	X
<i>Macrotis lagotis</i>	X	X
<i>Lasiiorhinus</i> sp.	—	X
<i>Bettongia lesueur</i>	X	XXX
<i>Lagorchestes hirsutus</i>	X	XXX
<i>Macropus rufus</i>	X	X
<i>Rattus villosissimus</i>	X	XX
<i>Notomys alexis</i>	XXX	XX

Table 5. Species representation in Holocene Uluru cave deposits (Baynes and Baird 1992) compared with the Mygoora LF.

Family	n species Uluru	n species Mygoora LF	Difference
Tachyglossidae	1	0	-1
Dasyuridae	10	3	-7
Peramelidae	3	0	-3
Thylacomyidae	1	1	0
Vombatidae	0	1	+1
Phalangeridae	1	0	-1
Potoroidae	1	1	0
Macropodidae	2	2	0
Muridae	10	2	-8
Canidae	1	0	-1

higher than in recent times, though no particular palaeoclimatic attributes can be inferred from these hardy and adaptable species. Southern hairy-nosed wombats live in parts of South Australia with little or no surface water and low mean annual rainfall. In contrast with the driest parts of their present range, the Erldunda lakes and Karinga Creek system are discharge zones for low salinity calcrete aquifers. Groundwater discharge sustains riparian vegetation even through long periods of drought, and this hydrogeological regime is one that preceded the accumulation of the Mygoora LF. Northern hairy-nosed wombats are also found in areas of high mean annual temperature, north of the Tropic of Capricorn in Queensland. Across their present range, hairy-nosed wombats are tolerant of extremes of temperature and aridity, so it seems unlikely that a hypothetical climate change in the direction of aridification could have been directly responsible for their extirpation in central Australia. Wombats co-exist today with dingos on mainland Australia, and with devils, and until recently also with the Tasmanian 'wolf', *Thylacinus cynocephalus*, on Tasmania, so there is no reason to suppose that their demise in central Australia was related to displacements amongst the carnivores. The reasons for the regional demise of wombats therefore appear to lie elsewhere, perhaps with increased fire frequency associated with human occupation of the continental interior (e.g. Wasson 1989; Smith 1993).

The majority of vertebrate species in the Mygoora LF are burrowing forms that prefer stable or lightly consolidated, relatively deep, homogeneous sandy substrates. At present, the Mygoora Lake margins are spinifex-dominated mobile dunefields whose mobility is attributed primarily to a high frequency of wildfires throughout the Amadeus region. Frequent burning of arid shrubland drastically reduces local floral diversity and destabilises the soil (e.g. Wasson 1989), thus diminishing the available range of food plants and rendering the substrate unsuitable for burrow construction. Loss of vegetation would also have contributed to increased sediment yield, resulting in alluviation of drainages such as the Finke River system and comparable ones of the northern Simpson Desert, to the point that these rivers now terminate in floodout areas where runoff evaporates or dissipates into the desert sand. Expanding alluvial plains may have isolated colonies of wombats from each other. Should a local colony have failed, whatever the direct cause, recolonisation from other locales may not have been possible. Thus, frequent burning may have resulted in reduction and fragmentation of habitat suitable for wombats, to the point that they no longer occur over the central Australian massif.

## CONCLUDING REMARKS

The Mygoora LF is dominated by fossorial animals, or those known to inhabit established burrows, and the sedimentological indications are that skeletal remains were preserved within burrows. Consequently, the age of the fauna post-dates its host stratum, determined by OSL dating to be between  $12.1 \pm 0.5$  –  $9.3 \pm 0.6$  ka. The lighter-coloured modern dunes, having been stripped off the fossiliferous unit and currently mobile in the environs of the fossil sites, were considered unsuitable prospects for TL dates that might usefully constrain the minimum age of the fossils, but the feasibility of radiocarbon dating the fossils themselves would be worth investigating. Burrowing by animals and formation of rhizoconcretions both imply that the aeolian dunes comprising the host unit were stable for a substantial period or periods of time, and that a significant hiatus occurred between stabilisation of the host sediments and coverage by remobilised sand.

The presence of Tasmanian devils and absence of dingos may indicate an earlier rather than later Holocene minimum age, and an earlier relative age than the prehistoric (but undated) assemblages from Uluru and Kata Tjuta described by Baynes and Baird (1992). On a balance of probabilities, we postulate a latest Pleistocene or early Holocene age for the Mygoora Local Fauna. The local extinction of *Sarcophilus* and *Lasiornhinus* is unlikely to have been due to climatic change. Tasmanian devils may have been displaced by the introduction of the dingo in the early to mid Holocene and the hairy-nosed wombat may have been extirpated by habitat fragmentation and degradation by an accelerated fire regime.

## ACKNOWLEDGMENTS

Our thanks to Ian and Jared Archibald for assistance in the field. Our gratitude to Anne and John Stanes on Lyndavale Station, and the Kilgariff family on neighbouring Erldunda Station, for many years of support of our surveying and research activities. Professor J.R. Prescott and Dr F.M. Williams (Adelaide University) are thanked for undertaking the OSL dating. Gavin Prideaux and Alex Baynes provided us with very helpful and thought-provoking reviews, and we are much obliged to Alex Baynes for drawing our attention to various additional relevant publications.

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Accepted 30 October 2002





## GUIDE TO AUTHORS

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Where appropriate, articles should conform to the sequence: Title, Author's name and address, Abstract, Keywords, Introduction, Materials and Methods, Results / Findings, Discussion, Conclusions, Acknowledgments, References, Appendices.

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Crowley, L.M. 1949. Working class conditions in Australia, 1788-1851. Unpublished PhD thesis. University of Melbourne.

Sadlier, R.A. 1990. A new species of scincid lizard from western Arnhem Land, Northern Territory. *The Beagle, Records of the Northern Territory Museum of Arts and Sciences* 7(2): 29-33.



# The Beagle

Records of the Museums and Art Galleries  
of the Northern Territory

Volume 18, December 2002

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